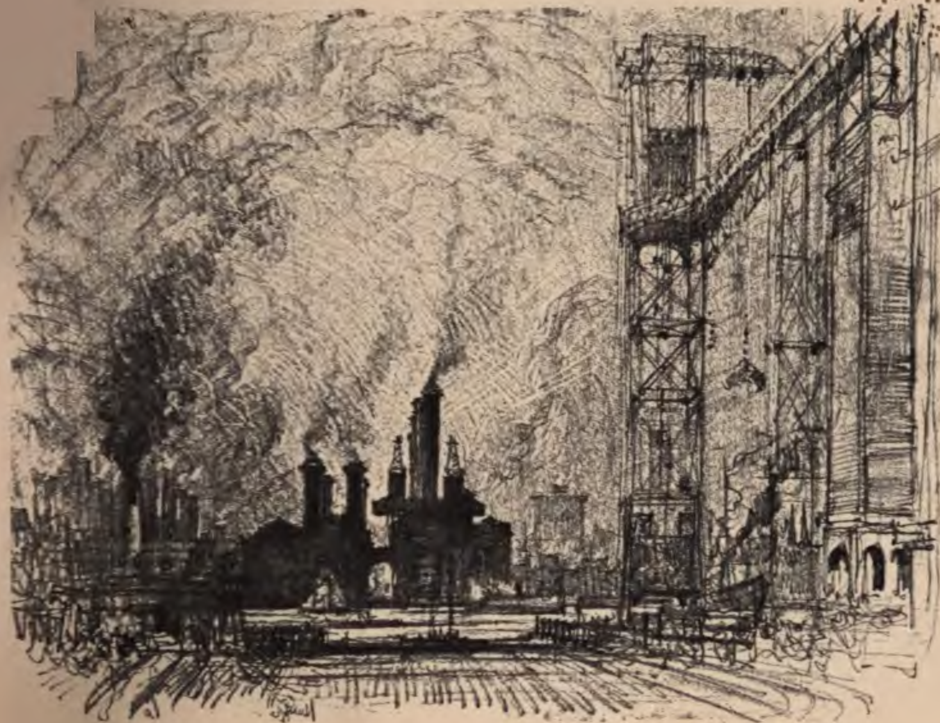
Thirty Years of New York
1882–1912



WATERSIDE FROM THE OPPOSITE SHORE

Drawn by Joseph Pennell

Thirty Years of New York

1882–1912

Being a
History of Electrical Development
in Manhattan and the Bronx

Press of
The New York Edison Company

To a city whose whole story has been one of marvelous changes, this partial account of its last thirty years is dedicated. Not that the volume seeks to tell all the wonders, contrasts, tragedies and triumphs of the towering stronghold which has grown up on the island Peter Minuit bought; but it will have served its purpose if it succeeds in describing the influence of a modern magic under the spell of which the city lives today.

ACKNOWLEDGMENT is gratefully made for assistance furnished, both through personal recollections and valuable documents, by Mr W S Andrews, Mr Charles S Bradley, Mr Charles L Clarke, Mr W J Hammer, Mr Samuel Insull, Mr E H Johnson, Mr T C Martin, Mr William H Meadowcroft, Mr A T Moore, Dr S S Wheeler and staff members of The New York Edison Company.

The following books and periodicals have been consulted:

Annual Reports of the Edison Electric Illuminating Company, 1881–1898.

Annual Reports of the Edison Electric Light Company, 1878–1883.

Edisonia. Compiled under the auspices of the Association of Edison Illuminating Companies.

Edison, his Life and Inventions. By Frank Lewis Dyer and Thomas Commerford Martin.

Skeleton Construction in Building. By William H Birkmire.

The Planning and Construction of High Office Buildings. By William H Birkmire.

The Tenement-House Problem. Edited by Robert W De Forest and Lawrence Veiller.

The New York Electrical Handbook. Published by the American Institute of Electrical Engineers.

Scribner's Magazine, 1878–1881.

Harper's Magazine, 1880.

New York daily papers for 1882—the *Sun,* the *Herald,* the *World,* the *Times* and the *Tribune.*

Harper's Weekly, 1880.

Leslie's Weekly, 1880.

The Scientific American, 1882.

Table of Contents

Thirty Years of New York

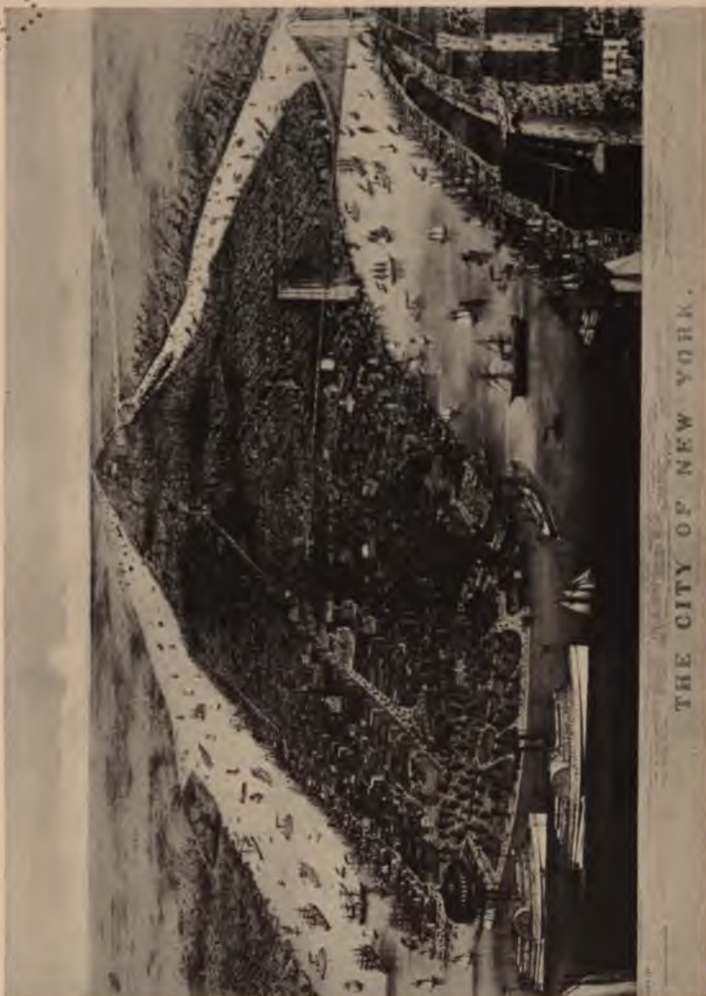
1882–1912

Looking Backward

A NEW YORK without skyscrapers, without a great white way; a New York which knew not the shrieking honk nor the departing whiff of an automobile; a New York to which the rattle of countless typewriters and the imperious buzz of the telephone were all but strangers.

This was the city into which—in 1882—Thomas A Edison introduced his then recently perfected incandescent lights and his first central station. It was the inventor himself who superintended the laying of the current-bearing wires which were destined to reach out farther and farther, to weave themselves closer and closer until they should become a tingling network of nerves beneath the surface of the city, rendering it sensitive, alert, responsive; helping it to carry on its life, to fulfil its ambitions. And these nerves were to be factors in a great physical transformation. For the New York of 1882 differed vastly, in outward semblance at least, from the metropolis of 1912.

In 1882 it was a city of low sky-lines. Buildings, for the most part, went up as high as people found it convenient to climb the stairs—and then stopped. Visitors, who wanted a bird's-eye view of Manhattan Island, mounted to the observatory of Trinity



NEW YORK, ABOUT 1880

Church or hied themselves, perhaps seven stories up, to the dome of the Masonic Temple at Twenty-third Street and Sixth Avenue, where they would find "a magnificent panorama spread out far below." The spire of the Western Union Telegraph Company's Building, at Fulton and Dey Streets, was spoken of then as "towering above its surroundings."

Gothamites, secretly swelling the while with the pride of vicarious ownership, gazed up at the Equitable Building and its less than ten stories which, today, would stand knee-high to surrounding structures.

On Printing House Square was another "show building," housing the *Tribune*. Its walls, having no inner steel skeleton, were said to be thirteen feet thick at the street level, and from its pinnacle Whitelaw Reid, then editor-in-chief of the paper, took the appellation of "the man in the tall tower." In later years, so dwarfed did the tower feel itself among its recently arrived associates that it submitted to a surgical operation and had some ten or a dozen new stories inserted between its main structure and its spire!

As for the cobblestone streets of that time, they were notoriously dirty and ill kept; while the noise of traffic, crossing their humps and bumps, was accepted stoically as an evil which must be endured. In 1881 the block of Fifth Avenue between Twenty-sixth and Twenty-seventh Streets was paved with asphalt as an experiment. Many people complained that the new covering was too slippery, but others spoke gratefully of the lack of clatter due to its

smooth surface. It was even conjectured that laying streets with asphalt would reduce cab fares! This Utopian dream, however, was destined not to be fulfilled.

Since the coming of this modern paving, the elec-

THE STREETS

Mother of Family: "My dears, such is the selfishness of man that some people would even make the authorities deprive us of this luxury"

Harper's Weekly, January 24 1880

tion-night bonfire, that delight of the small boy and sometimes of the boy of larger growth, has fallen under a ban. But in the early eighties it absorbed the thoughts of youthful fire-worshipers for days before election. Woe betide the householder who had left an ash-barrel in his front yard. In those palmy days

no paternal board of health or department of street cleaning had decreed that only metal ash-cans might be used. That night, the foresighted property owner locked his cellar board safely behind his basement gate, and then walked out to watch the destructive instinct of Young America run wild. Near every street corner the flames leaped high, fed principally on barrels and yet more barrels; and on any other burnable thing which could be pried from its moorings. Around the blazing heaps stood countless urchins thrilled to their finger-tips and shouting with joy. No doubt it was a very wanton, wasteful, dangerous custom in spite of its picturesqueness.

This was the era of the horse-car with its jangling bells and colored lights—red, green, blue, yellow, white—to indicate its destination. To be sure such a signal was not very bright, being radiated by a small oil lamp enclosed in a box behind a grimy pane of glass of the desired shade. But if the light was not effulgent, it was strong enough to shine out in a street illumined only by a few wind-blown gas-jets.

And the car horses, they struggled and slipped in the winter storms, and during "hot waves" in the summer they dropped dead in the streets. Every time a horse died, the traffic was blocked and crowds of hurried people, afraid of missing their ferries to Brooklyn or Jersey or their trains at the Grand Central Station, jumped off the cars and walked.

The greater part of these street railways ran no farther north than Fifty-ninth Street, though a few —the Third Avenue car with the green light for instance, and some cars of the Madison and Eighth

Avenue lines—ventured to Harlem Bridge or Macomb's Dam. A map of New York, intended for the use of strangers in 1880, went only as far as Seventieth Street. Turning it over, the visitor discovered on the back of the sheet a small plan of the rest of the city, together with a little outline of Brooklyn and Long Island.

A CHAPTER OF HEADERS
Scribner's Magazine, February 1880

The shopping district stretched from A T Stewart's at Broadway and Tenth Street up to Twenty-third Street, and this mile or so of great thoroughfare swarmed every afternoon, according to the guide-book, "with the beauty, fashion and wealth of New York." This was when men dressed for business in cutaways and "Prince Alberts" braided at

the edges, and women wore bustles and polonaises.

It was also the period of enthusiasm for lawn-tennis and high bicycles. Very popular were bicycle clubs, and long files of riders in variously colored uniforms wound their ways through parks and out into the suburbs on Saturdays and Sundays. A bugler generally headed the procession, those behind being compelled to follow his orders so as to prevent collisions. Of course century runs were well-nigh impossible and remained to be accomplished later on "safetys" which were geared; but fifty miles a day was not a rare record. The wicked small boy,—and envious—on beholding a cyclist, shouted, "Mister, your little wheel's loose!" instead of the "Get a horse" which greets automobiles today.

"OTHELLO'S OCCUPATION GONE"
Scribner's Magazine, February 1880

When people wanted to go to the theatre, there was "Esmeralda" at the Madison Square and "The Lights o' London" at Niblo's Garden Theatre. Women took a certain solid comfort in coming away from Clara Morris's performance of "Miss Multon" with red eyes and swollen cheeks. Then there was Booth's handsome theatre at Sixth Avenue and Twenty-third Street.

And Gilbert and Sullivan's "Patience" had just

BONFIRES ON ELECTION NIGHT

Leslie's Weekly, November 13 1880

come to town, bringing with it interest in the "esthetic" craze. To be long and limp, graceful, spineless and "artistic" was the aim of the esthete. At Daly's one might see Ada Rehan or perhaps the great Daly company in a big English melodrama like "Mankind," which played there in the fall of 1882. Judging from the following advertisement, any one who saw "Mankind" got his money's worth in sensations.

"Scene of the channel steamer. . . . The falling fog. . . . Attempted murder of the heroine by her husband who tosses her overboard. . . . Open sea. Woman struggling in the waves. . . . Her rescue just as her energies are about to forsake her."

In most instances the footlights of these theatres still burned gas, and enthusiasts were wont to say they loved to go to the theatre if only to smell the lights.

"Asides" in plays were the fashion. Characters had the habit of uttering their most secret thoughts in tones which could scarcely have failed to be audible to other characters standing near them; but this was done with utmost safety because of the convention which ruled that it was unfair for any one except the audience to notice these little confidential soliloquies. As high an authority on the drama as Brander Matthews states that the credit for banishing the "aside" should be divided equally between Ibsen and Edison. For, says Mr Matthews, when incandescent lamps accomplished the full and clear lighting of the stage, it then became possible to see slight changes of expression on the faces of the act-

ors. After that it was unnecessary to write speeches explaining what characters were thinking, because their faces told.

The East Side in 1882 was already a densely populated region into which the conservative and respectable residents of more favored localities rarely

A SALOON IN BOTTLE ALLEY
From a sketch by C A Keetles. *Harper's Weekly*, February 28 1880

penetrated. There were many rear tenements, and the building of double-deckers containing dark, unventilated rooms was still permitted. Poverty, uncleanliness, disease and misery were taken for granted in the East Side. No settlement workers were there, no vacation schools, no recreation centers.

To be sure, the squalid, revolting Five Points region had been regenerated and on the very spot

which years before had reeked of crime, disease and misfortune, stood the Five Points House of Industry. But, in 1880, Bottle Alley, a lane leading off Baxter Street, was not a pretty sight. Writers, however, used to go there in search of "local color." That they found it in abundance is made plain by a leaf from the experiences of a *Harper's Weekly* artist. He went into a saloon where he found men and women, drunk. As for the room: "It had a rotten board floor and low, blackened ceiling. The plastered walls, cracked, broken, and grimy, were sickening to look at. Millions of roaches crawled over walls and ceiling and gathered in black clusters over the solitary smoking candle that dimly lighted the room." Who will deny that better lighting, which makes dirt visible, combined with popular acceptance of the germ theory, have not lifted by the bootstraps the sanitary standards of New York in the space of one generation?

But in the midst of the busy life of the community thirty years ago, forces were already at work which were to remake it into the city of today.

The first of these was the annexation of the villages of Kingsbridge, Morrisania and West Farms. This was in 1873. Immediately, the town began to stretch itself, to spread northward, glad of a new world to conquer.

Then arose a demand for rapid transit, which was answered by the building of the elevated railroads in the later seventies. Mechanical traction on surface lines was still a thing of the future, for it was not till 1885 that the first cable cars were installed,

PROPOSED ARCADE RAILWAY UNDER BROADWAY

Begun in 1870, and abandoned in 1876,—now being incorporated in the new Broadway subway
From a lithograph at the Public Library

these being on the One Hundred and Twenty-fifth Street and Amsterdam Avenue lines of the Third Avenue Railroad Company. At the same time, a horse railway was preparing on Broadway. And it was not until ten years later—in 1895—that the underground trolley made its entrance into New York, as the result of a successful experiment on the Lenox Avenue line in Harlem.

In 1876 the New York Elevated advertised "forty through trains per day—Battery to Fifty-ninth Street." But it was Harlem which really needed the elevateds, and before 1880 Harlem got them, fare on these roads being ten cents, except during rush hours when it was reduced to five. This was the beginning of real rapid transit, which was to lead in after years to the present system of subways, tunnels and bridges; a system which is still only in the making.

Oddly enough, under the feet of people who walked Broadway in 1882, there hid an actual foreshadowing of the subway; for, beneath Broadway near Warren Street was a forgotten tunnel, begun in 1870 and abandoned a few years later, which had been part of a projected underground railway. There it lay, the crushed hope of its inventor; his dream, pronounced chimerical, impractical, a failure. And today it is being made part of the new Broadway subway; for it is not only the coral that builds itself up on the dead bodies of past generations.

Another form of rapid transit development which was powerfully to influence the life and history of New York was the Brooklyn Bridge. In 1882 it was

NEW YORK FROM BROOKLYN HEIGHTS
Nueva York Ilustrada, 1886

nearing completion, promising before long to relieve the over-crowded ferries, to bring New York and Brooklyn closer, and eventually to join the communities politically. It stood there with its graceful towers and web-like cables, the wonder of its time, an engineering feat of the highest rank. And as people watched it receive its finishing touches, only the unimaginative failed to think of John A Roebling, the man who planned it all and who died before a stone of it was laid or a cable spun.

The entering wedge of still another change in daily life had already been driven into the city. This was the telephone. In 1879 the first New York exchange had been opened at 82 Nassau Street, and the list of firms and individuals who had thus been

placed within speaking distance of each other contained 252 names! This contrasts quaintly with the fact that today a subscriber to the same institution may be connected with many million people; and it reminds one sharply that in the early eighties the telephone was indeed an infant industry. But it was

OUR STREET COMMISSIONERS
"Come, gentlemen, wake up. It is Pay Day"
Drawn by Wopsey. *Harper's Weekly*, January 24 1880

VIEW OF BROADWAY WITH PROPOSED ELEVATED RAILWAY, 1848

From a lithograph at the Public Library

a lusty infant, already talking for itself with considerable ease and assiduity, and destined to play an important part in the progress of the metropolis.

Finally, there were already at hand signs of a new era in illumination; and not in illumination alone, but also in an equally important, hitherto unworked field, the transmission of power. For Thomas A Edison was laboring in the trenches in New York streets, helping to lay the wires of his new electric system. It is true that some of the principal arteries of traffic had already been lighted with arc lamps and that these had been hailed as proof of the practicability of electric street illumination; but without Edison's incandescent lamp, his dynamo for generating current, and his carefully planned distributing system, this new source of light could not have been made safe, convenient and cheap; a universal understudy for the sun wherever a substitute should be needed.

Thus another step in man's toilsome climb up from primeval darkness—the darkness of ignorance as well as of night—was about to be accomplished. These, then, were the factors, already beginning to be felt, which would remold New York in the next three decades. They may be summed up roughly under three heads: expansion; rapid transit; and the use of electricity as a new weapon with which man might combat his age-long enemies—time, distance and darkness.

If the questions of expansion and rapid transit are looked into a little more closely, it will be seen that they, too, hark back to electricity; for further

HOW HORSES ARE ABUSED

From a sketch by Thomas Worth. *Harper's Weekly* March 27 1880

growth of the city was to be dependent on still better transit facilities and these, in turn, could only be obtained by the use of electric current. When it is recalled that every tunnel and subway in Greater New York has been bored with the help of current from the Edison central station; that elevated roads and trolleys are now being run by methods similar to those perfected by Edison, but which he was unable to induce the city to put into practice; that Edison was the inventor of multiple telegraphy; that his carbon button was of the highest importance in the practical success of the telephone; that streets, offices, show-windows, theatres and factories are lit by his lights; that countless motors are driven with power coming over his wires; that he is the founder of the motion picture, and the deviser of the phonograph, then, indeed, it becomes undeniably apparent that every phase of life in our great city is touched by his genius, and we realize something of the debt which New York owes to the man who, in 1882, was spoken of as "the wizard of Menlo Park."

The Beginning of Edison Service

ON September 4 1882, at three o'clock in the afternoon, current was turned on at the first Edison central station in New York City, 257 Pearl Street. Next day the papers were full of accounts of the new incandescent lights.

The *Tribune's* headline read: "Electricity Instead of Gas. In place of the usual gas fixtures," the report stated, "were those of the Edison Electric Illuminating Company, each lamp shedding its light from a small blazing horseshoe that glowed within a pear-shaped globe, pendant beneath a porcelain shade."

The *Sun* story contained a delightful glimpse of the inventor of the new system, as well as testimony to the difficulties of electrical work at that time. "Mr. Edison was seen by a reporter," read the *Sun*. "He wore a white, high crowned derby hat and collarless shirt. 'I have accomplished all I promised,' he said. . . . 'We have a greater demand for light than we can supply at present owing to insufficiency of men to put down the wires. We have to educate the men to the use and management of our machinery. We have only one experienced engineer here now. A man came down from our machine-shop in Goerck Street the other day and put his oil can between two conductors. He was a

PRINTING HOUSE SQUARE, 1864-65

From a lithograph at the Public Library

badly frightened man a second later, for the can melted away as quickly as the oil it contained. Another workman, while employed at a wire in Fulton Street, used a screw-driver. He was surprised to see his screw-driver burn away, and returned to the station in great haste to know what was the matter.' " Later in the same article was information regarding the equipment of the central station and the buildings it supplied. "Two engines were started last evening. The Drexel Building containing one hundred lights, the 'Times' office, the Park Bank, and the 'Herald' office were among the places lighted last night by currents from the station in Pearl Street."

The *Herald* told of "the dim flicker of gas supplanted by a steady glare, bright and mellow,—Mr. Edison stood in the workshop at 257 Pearl Street, in his shirt-sleeves superintending the work. Mr. Edison said that care would be taken to watch all influences that would offset the light, and doubtless new information tending to make it even more perfect would be gleaned." A bit of unconscious humor is dropped in by the somewhat condescending statement: "Last night it was fairly demonstrated that the Edison light had a very fair degree of success."

The Times Building was outside the district supplied by the Pearl Street station. Accordingly, Edison had fitted up this office with a separate plant, and the *Times* described the lights thus installed with what seems today to be a delectably rustic simplicity. "The whole lamp looks so much like a gas

EDISON'S HOME, MENLO PARK, NEW JERSEY
From a sketch by Theodore R Davis. *Harper's Weekly*, January 3 1880

burner surmounted by a shade that nine people out of ten would not have known the rooms were lighted by electricity except that the light was more brilliant than gas and a hundred times steadier. To turn on the light nothing is required but to turn the thumb-screw, no matches are needed, no patent appliances. As soon as it is dark enough to need artificial light, you turn the thumb-screw and the light is there; no nauseous smell, no flicker, no glare."

In the same article is an almost pathetic expression of the gratitude of old newspaper men for the new method of illumination. It must be remembered that in those days work on a morning paper had been the ruin of many a pair of eyes. "It seemed almost like writing by daylight to have a light with-

out a particle of flicker and with scarcely any heat to make the head ache. The lights in the Times Building were tested by men who have battered their eyes sufficiently by years of night work to know the good and bad points of a lamp; and the decision was unanimously in favor of the Edison electric lamp as against gas."

About two dozen men were present at 257 Pearl Street on the afternoon of September 4 1882, when the current was turned on. As nearly as can be learned this group included, besides Edison himself: Mr E H Johnson; Mr Charles L Clarke, the engineer of the Edison Electric Illuminating Company; Dr S S Wheeler; Mr Charles S Bradley; Mr Samuel Insull; Mr J W Lieb, Jr; Mr Francis Jehl; Mr Charles Batchelor; Mr Calvin Goddard; Mr W H Meadowcroft; Mr Julius Hornig, engineer in local charge of the station construction, and his assistant Mr H M Byllesby; Mr W A Anderson of the Board of Fire Underwriters; Mr Charles Dean of the Goerck Street shops; Mr Wetzler of the *Electrical World;* Mr John Kruesi; Mr S Bergmann; Mr H A Campbell; Mr F R Upton; Mr John Langton who worked with Kruesi; and Mr "Jack" Hood, the old Scotch engineer from Menlo Park.

A little later in the same afternoon, Edison joined Mr J Pierpont Morgan at the latter's office. Mr E H Johnson and Mr Charles S Bradley were there also.

Nowadays, the number of people who assert that their buildings were among those lighted by the

original Edison Service is almost as great as the multitudinous descendants of Mayflower progenitors. The earliest list of Edison customers comprises many whose offices had not been connected by the night of September 4, but who became patrons of the incandescent lamp shortly afterward. According to the newspapers of 1882, the edifices "among those present" at the opening of Edison Service, were the Polhemus Building, the Barnes Building, Greene Sons, Washburne and Moen, the *Herald* office, and the great Drexel Building, headquarters of Drexel, Morgan & Company. This last structure was then one of New York's show places, and every one knew it had cost $700,000. The lighting of it was considered an achievement because of its great size! It was equipped with 106 lamps,—a small enough outfit as compared with installations running up into the thousands in large office buildings today.

The rest of the places where Edison lights glowed that first night were grouped in the newspaper accounts under that convenient, inglorious phrase "and others." The *World,* however, said: "Most of the principal stores in Fulton Street from Nassau Street to East River were last evening for the first time lighted by the Edison electric light."

The Pearl Street central station was a double brick building, 255 and 257, of the warehouse type and four stories high, with a fire wall separating its two parts. One of these was used as a storehouse for underground tubes and other supplies, and the other had been converted into the station itself. Since the old walls and floors were not strong

enough to stand the strain of the machinery to be arranged there, the entire interior of 257 had been torn out and rebuilt on a foundation of steel girders and columns, reinforced by concrete flooring, and this was so constructed as to be independent of the original walls. Thus revamped, the old warehouse, purchased in May 1881, was ready for the installation of steam-boilers in the basement and of six generators on the second floor. These historic six, nicknamed "Jumbos," were the marvels of their day; so that even people who knew little or nothing about electricity, mentioned with awe the fact that each one of Edison's new dynamo-electric machines had a capacity of 125 horse-power, and that its armature alone—they used the word "armature" glibly enough though they were a little hazy as to its meaning—weighed six tons.

BROADWAY NEAR ST PAUL'S CHURCH
Nueva York Ilustrada, 1886

These six generators, then, were the pulses of the first Edison Service. In them and in the magic little incandescent lamps which they fed with light-giving "juice," was centered the interest of the general public.

But to bring them into being, to make possible

THE DYNAMO ROOM
First Edison Electric Lighting Station in New York
Scientific American, August 26 1882

their use as the beginning and end of a successful system of illumination in New York City, had taken the time and patience, the enthusiasm and faith of many men, spurred on always by the genius and unflagging resourcefulness of Edison himself.

In the fall of 1878, the inventor had mapped out a program of research and experimentation which was to result in the apparently-so-easily-accomplished turning on of lights from the Pearl Street

station on the memorable fourth of September, four years later. This program included the invention and perfection of the lamp itself; the planning of a distributing system which should be commercially practical; the providing for underground conductors which could be tapped at convenient intervals to supply consumers; the arrangement of devices to make lamps give an even and equal supply of light, regardless of their relative distance from the central station; the working out of a meter to measure the current consumed by each customer; the designing of an adequate dynamo with which to convert steam-power into electrical energy; and last, but very important, the planning of safety appliances so that persons and property might not be injured by the use of the new illuminating method.

Without tracing one by one the accomplishment of each of these undertakings, it is perhaps best to recognize the fact that, when the Edison Electric Illuminating Company of New York was organized in 1880, the greatest difficulty which faced it was that of carrying out an underground system. High authorities on electrical matters—and at that period this meant chiefly people interested in telegraphy—were of the opinion that it would be impossible to build an underground network of mains and feeders which would supply current at what was then considered a very high potential, without danger of great loss through leakage. These experts doubted whether such a system could be made sufficiently convenient and cheap to be a commercial success.

Much credit, then, should go to the financiers

who, farther sighted and fuller of faith than their contemporaries, subscribed to the stock of the Illuminating Company, thereby materially helping Edison to demonstrate the effectiveness of his plans in the face of unbelief.

The incorporators of the company were: Mr Tracy R Edson; Mr James H Banker; Mr Robert L Cutting, Jr; Mr E P Fabbri, who was J Pierpont Morgan's partner; Mr J F Navarro, also connected with Drexel, Morgan & Company; Mr Grosvenor P Lowry; and Mr Nathan G Miller. The first meeting for the election of officers was held on December 20 1880, the following directors being present: Mr Tracy R Edson, Mr Henry Villard, Major S B Eaton, Mr E P Fabbri, Mr R M Gallaway, Dr James O Green, Mr Nathan G Miller and Mr Robert L Cutting, Jr. Dr Norvin Green, afterward president of the Western Union Telegraph Company, was chosen for president of the Illuminating Company, with Mr Calvin Goddard as secretary and Mr E P Fabbri as treasurer.

On March 23 1881, Major S B Eaton was elected vice-president of the Edison Electric Illuminating Company, and at the directors' meeting, held on December 16 of that year, Thomas A Edison was "appointed engineer."

The board of directors responsible for the purchase of the original Pearl Street property, included: Dr Norvin Green, Major S B Eaton, Mr J F Navarro, Mr Grosvenor P Lowry, Mr Nathan G Miller, Mr Thomas A Edison, Mr E P Fabbri, Mr Henry Villard, Mr Robert L Cutting, Jr, Mr

James H Banker, Mr Calvin Goddard and Mr William H Meadowcroft.

The streets of New York in the early eighties were disfigured by rows of poles from which were strung telegraph and telephone wires, besides those of various burglar, fire-alarm and stock-ticker companies. In many instances, these wires were so numerous as to darken the streets and were often so poorly insulated as to become dangerous when they broke or sagged.

In spite of this, Edison's scheme of underground transmission was considerably ridiculed. But, undisturbed by opposition and ignorance on the part of people in general, he continued to insist that the only safe place for electric wires in a large city was under the streets. "Why, you don't lift water-pipes and gas-pipes up on stilts," he used to exclaim.

His way of looking at the question proved itself when the city finally compelled the removal of telegraph poles, with all their accompanying wires, and the building of underground conduits which are now used not only by the Edison Company, but also by telephone, telegraph and ticker concerns. In fact, so firmly did the once scoffing public come to believe in the superiority of underground wires, that when electric street railways were first suggested for New York, citizens refused to have the overhead trolley introduced. As late as 1893 they preferred the Broadway cable line with its "dead man's curve" to the anathematized overhanging wires. It was only the conduit system for electric cars—combining the slot arrangement of the cable with the flexi-

bility of electric traction—which finally brought about the passing of the dangerous crossing at Union Square.

In the summer of 1881, the process of laying street mains in the First District was begun. This section had an area of about one square mile and was bounded by Wall, Spruce, Nassau and Ferry Streets, and the East River. The region had been selected particularly because it was New York's business center and because the successful lighting of such a district could not fail to attract wide attention. There was also a secondary reason, one which reveals Edison's Scotch canniness. Many office buildings in this neighborhood were deserted at night, and this made it possible to test the lights without attracting attention. This region was canvassed to see how many lights and how much power were then being used. The load was represented by a series of resistances placed upon an enlarged map of the

EDISON IN 1882
From a photograph in the possession of Mr W H Meadowcroft

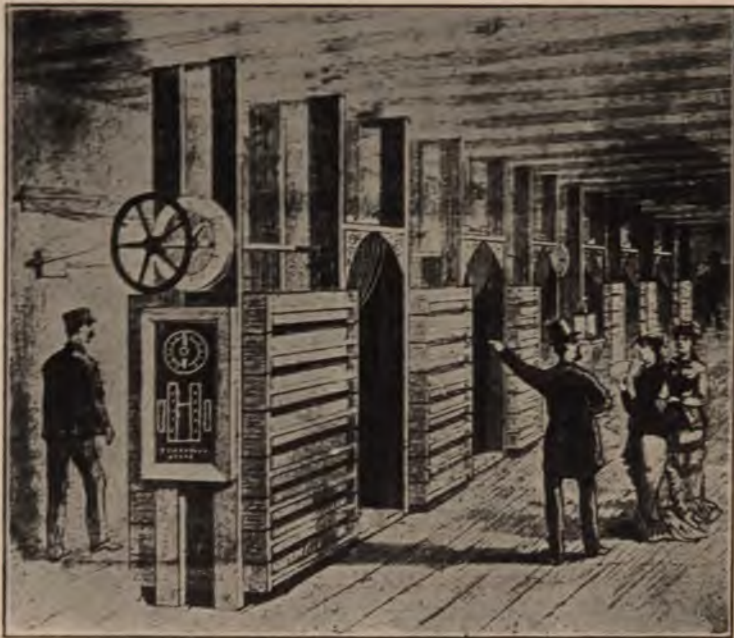
district, and this diagram was set up in Edisons' laboratory at Menlo Park. These resistances were connected to an imaginary system of mains and feeders.

A German, Dr Claudius, worked up the data by which the two-wire underground conductors for the First District were originally made, the conductors, themselves, being manufactured in a building at 65 Washington Street. The workshop was just six inches narrower than the standard length of conductors, so that the tubes, to be turned around, had to be taken out through a window.

Of course conduits of the present style beneath the streets had not been thought of in 1882. Instead, trenches were dug, and in these twenty-foot length pipes were laid. Through these pipes were then drawn the conductors,—two half-round copper wires, kept in place first by heavy cardboard, but afterward by rope—and then a preparation of asphaltum and linseed oil was forced into the piping for insulation.

Mr John Kruesi had been entrusted with much of the work of laying the pipes, but Edison himself often climbed down into the ditches to help in various difficulties and to solve knotty problems. In fact, during the summers of 1881 and 1882, he often spent as many as four nights a week in the trenches with Kruesi.

In those days "graft"—the word unknown but the fact most familiar—was not in especially bad odor. One day, during the laying of these underground tubes, Edison received word that he must appear at the office of the Commissioner of Public Works. At



PRIMITIVE REGULATING APPARATUS USED AT THE PEARL STREET STATION IN 1882

the appointed time he went, and this is his story of what happened as it is told in the Edison biography: "The commissioner said to me, 'You are putting down these tubes. The Department of Public Works requires that you should have five inspectors to look after this work, and their salary shall be $5 per day, payable at the end of each week. Good morning.' I went out very much crestfallen, thinking I would be delayed and harassed in the work which I was anxious to finish, and was doing night and day. We watched patiently for those inspectors to appear. The only appearance they made was to draw their pay Saturday afternoon."

The manufacturing of conductors brings up still another phase in the process of introducing an entirely new lighting system, the question of making and providing supplies. On this point no one is better able to speak than Mr Samuel Insull, who was at that time Edison's secretary and right-hand man, as well as secretary of the Electric Tube Company. Recently, in talking over the days when Edison Service was preparing, he remarked:

"It should be remembered that at the time the construction of the first Pearl Street station started, there were no manufacturing establishments on either side of the Atlantic to produce the electrical machinery required. As a matter of fact, scarcely any of the apparatus needed in the operation of the station was even invented, to say nothing of being designed. There was no shop where you could get dynamo machines for generating current of such large capacities as those needed; there was no place where the underground conductors required could be procured; there was nothing but a lit-

BATTERY OF A THOUSAND LAMPS ON AN UPPER FLOOR AT 257 PEARL STREET

tle building where incandescent lamps were being made at Menlo Park, to supply the lamps necessary for the service. All that existed was the station at Menlo Park, which, while being a working practical example of what could be done, was, after all, nothing but an experimental plant. When Mr Edison started to build the Pearl Street station and the First District system, he was on the threshold of a new art, of a new industry, which had to be created in all its component parts, before it was possible to operate the First District station successfully.

"Then followed in rapid succession the establishment of the Electric Tube Works at 65 Washington Street, for the manufacture of underground conductors; the establishment of the Edison Machine Works, on Goerck Street, New York, for the manufacture of large electric generators; the establishment of the Lamp Works at East Newark, for the manufacture of incandescent lamps, and the remodeling of the business of Bergman & Co, for the manufacture of small electrical sundries and electroliers.

"Whilst the gentlemen who had supplied the capital for Mr Edison's experiments, through the medium of the Edison Electric Light Company, subscribed the original million dollars, the capital of the Edison Electric Illuminating Company of New York, the money that was put into the manufacturing establishments which had to be created in order to produce the plant, was supplied out of the personal resources of Mr Thomas A Edison. Later on, when the original capital of the Edison Elec-

tric Illuminating Company of New York was exhausted, he really financed that company through his electrical manufacturing concerns, until the business of electricity supply was demonstrated to be a commercial proposition."

Before leaving the realm of personal reminiscence, the statements of two other men who took part in preparing the First District system will prove interesting. Mr J W Lieb, Jr, first electrician of the Pearl Street station and now third vice-president of The New York Edison Company, realizes keenly the contrasts between the yesterday and the today of the electric industry.

"Owing to the wonderful progress"—he says—"made toward perfecting every detail connected with central station construction, equipment and operation, from the boilers through the many devices necessary for generating current and for its transmission, distribution and delivery to customers' premises, we are apt to overlook the enormous difficulties with which pioneers in the art had to contend.

"Without a clear idea of what was required and without any engineering precedents to follow, central station pioneering was largely a groping in the dark, an endeavor to meet intuitively or by unlimited expenditure of personal energy and resourcefulness, the unexpected problems which daily presented themselves, and which often needed instant solution.

"The Jumbo dynamo as finally installed in the Pearl Street station had eight upper and four lower

magnets. A very curious discussion arose among scientists of the time as to why the field had been designed to be so unsymmetrical, some authorities going so far as to explain that it was a beautiful application of scientific principles and practical ingenuity; for it was said that the idea was to produce a stronger upward field pull in order to counteract the enormous weight of the armature, and, by offsetting it, to reduce friction on the bearings! As a matter of fact, the very first large, connected dynamo had a perfectly symmetrical field but it was found necessary subsequently to add to the magnetic field circuit. It was increased by adding field cores to the upper side, so as to give the larger number of ampere terms required for the increased voltage which it was necessary to demand of the dynamo, this being 110 to 115 volts instead of 100 to 105 volts for which the first machines were built. These magnets were immense pieces of wrought iron with cores nine inches in diameter and fifty-seven inches long. The field magnets were really so long that a consequent pole developed at about three quarters of the length of the core, indicating an undesirable length of the magnetic circuit.

"While experiments and tests were under way at Pearl Street, preparatory to starting up, there was considerable talk in newspapers and popular magazines concerning hypnotism, mesmerism and kindred subjects, together with the effects of magnetism on human beings. The colossal fields of the 'Jumbos'—the largest electro-magnets that had ever been constructed—afforded excellent opportunity for a

test. When the armature was removed, the big cylindrical gap that was left gave plenty of room to accommodate a mattress as a bed. To make a trial, I slept all night in the 'air gap' with the field fully excited. On waking after a nap of four or five hours —for that was all the sleep any one ever got in those trying days—my sensations were not unusual; neither was my 'big head' feeling changed for it was a sort of chronic state with most of us at the time!

"The commutation of the current on the dynamos was a matter of grave concern, in fact the sparking was so serious that it was impossible to operate the dynamos at full load without the use of mercury on the commutators. After the first coat, which was applied by amalgamating the surface of the copper segments, the metallic mercury was allowed to drop from a chamois bag held over the commutator while the dynamos were in motion, spreading a thin film over the commutator. During the operation, sparking was so intense that a thin haze of mercury vapor ascended like a cloud. Many of those engaged in the earlier tests and experiments with these machines had their teeth seriously affected by salivation from the mercury fumes. Numerous forms of brushes were devised to reduce the sparking. One form divided the brush into four or five layers, each insulated from the other, thus giving a resistance path through the brush, where in multiple with the armature winding at the point of commutation.

"It was not until some time after the station opened that a very primitive form of ampere-meter, designed by Mr Edison, was installed. It consisted

of a very small diamond shape armature with a pointer, held in the field of a large permanent horseshoe magnet. This simple ampere-meter was fastened to the main bus-bars of the station, the permanent magnet providing the fixed field, the current in the bar deviating the armature so that the pointer on the properly graduated scale read off the current flowing through the bus-bar.

"As we look back upon those early stages of the art we must perforce marvel at the rugged practical sense, the sound engineering judgment and the keen commercial grasp exhibited by the master mind of Thomas Alva Edison, in working out every feature of what was a marvelously complete and perfect lighting system."

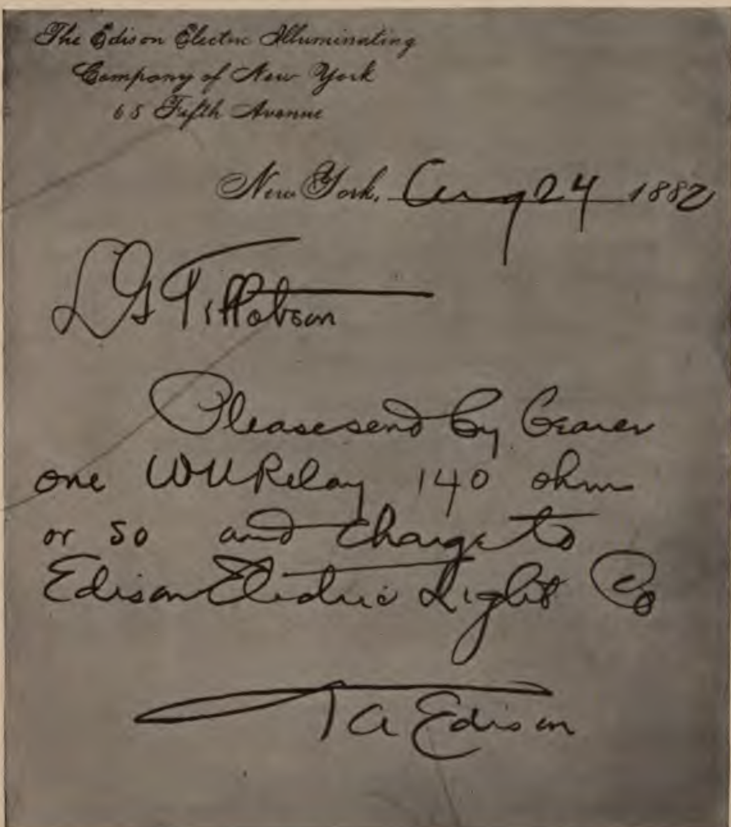
Dr S S Wheeler, another member of Edison's forces in the old days, and now president of the Crocker-Wheeler Company, is equally enthusiastic in his admiration for the inventor under whom he had his early training, for he said recently:

"I have always regarded my experience as a member of Mr Edison's staff as having been of the greatest value to me, and I attribute to it whatever engineering ability I now possess. For previous to that time, electrical work was carried on by rule of thumb and was done by so-called practical men, whose skill was generally that of linemen.

"When I joined the Edison forces, however, I found that correct application of theory was the preferred method of dealing with each subject; that those who looked at problems from this viewpoint were sought after and appreciated. This different

atmosphere, which tended to bring about a scientific basis of station operation, awakened all my enthusiasm and made an impression on me that I shall never forget.

"Opening the first Edison station with all its tremendous new possibilities and unsolved engineer-



The Edison Electric Illuminating
Company of New York
65 Fifth Avenue

New York, Aug 24 1882

L G Tillotson

Please send by bearer
one W U Relay 140 ohm
or so and charge to
Edison Electric Light Co

T A Edison

A MEMENTO OF THE DAYS PREVIOUS TO THE PEARL STREET STATION OPENING

Edison, in need of a relay for testing, obtained one from the Western Union

From the Scrap Book of Dr S S Wheeler

ing problems, was like riding to a new country on the cow-catcher of the first locomotive ever built, or like taking possession of a fully equipped laboratory that was to be devoted to some entirely new science, in which no work had been done except to recognize the existence of that science.

"To any one who wants to know whether Edison was present at the starting of the station or was elsewhere, I can answer very definitely that he was there 'on the job,' and that he stayed there a week. When time had elapsed even beyond Edison's limit of endurance, some one was sent out to get him a cot on which he slept close beside the running engines. The rest of the crew crawled in on the lower row of field-magnet coils of the dynamos, which was considered a nice, warm place, though a little bumpy. I went to sleep standing up leaning against a door frame, after forty-eight hours."

Among the difficulties to be met and overcome before the First District station could be put into operation, was the scarcity of experienced workmen. A night school had to be established at 65 Fifth Avenue—that hive of industry and interest in all electric lighting questions—and Mr E H Johnson, fresh from his successes in England, was made head of the school with Mr C L Clarke as instructor on engineering problems. Wiremen, who had already done work on telephone, burglar-alarm and messenger-call systems, were the most hopeful material out of which to make electric-light men. Accordingly they, together with students from technical schools, were instructed in the A B C's of the new

industry; and what they lacked in full scientific knowledge of their subject, they made up in enthusiasm and ambition. As their skill increased, the actual work of installation in the downtown district progressed rapidly. The workers were sometimes able to lay a thousand feet of iron piping in a day; while in the month of May 1882, 7923 feet were put into place.

Education of the general public was being carried on at the same time, in the same Fifth Avenue building. Every evening the incandescent lamps were turned on at "65" and all sorts and conditions of people were shown through the house until midnight under the guidance of Edison's friends and associates. Many were the questions put by amazed beholders of the new light. "Won't it explode?" "Don't you use any matches?" "Can you put in another bulb if that one gets broken?" "Is it safe in a thunder-storm?" These, and many more inquiries were patiently answered by the missionaries of the new gospel of light, anxious to convert the ultimate consumer.

Thus, step by step, the beginning of the Edison system in New York City was accomplished, and on September 4 1882, the turning on of 400 lamps from the Pearl Street station was a triumph; a triumph not only for the inventor himself, not only for his co-laborers, not only for the men who believing in him had opened their purses, but also for the city which was to reap the benefit of their efforts and their faith.

The first Edison central station which entered

upon its career that day supplied current continuously day and night, with but two interruptions until 1895, when the building was given up because it had been outgrown. Of the two breaks in its service one happened in 1883 and lasted three hours, while the

RUSH HOURS, 1882
Drawing by Thomas Nast, *Harper's Bazaar*

other, occasioned by the serious fire of January 2 1890, lasted less than half a day. That a fire which destroyed the central station should have occasioned so short a delay was due both to the presence of an auxiliary plant which had been opened on Liberty Street; and to the prompt action of Mr Samuel In-

sull, who, as vice-president of the Edison General Electric Company at Schenectady, had new dynamos on the way before the fire had been extinguished.

In the blaze, five "jumbos" were destroyed while No 9, the sole survivor, was only saved because it stood near a front window and the firemen were able to play a hose behind it, thereby cutting it off from the flames. A few years later No 9—a giant in its day, but long since superseded by the "Big Engine" and "Big Harry"—was given honorable dismissal and furnished with a home at Shadyside. Now "Jumbo" makes his appearance only on state occasions as an exhibit of the first days of the electric lighting industry.

But though Edison's original dynamos have been succeeded by larger machines, the tremendous Edison system of today in New York City is conducted according to principles which he developed and put into practice in 1882. It was he who planned the placing of wires beneath the ground; the direct connected unit; the feeder system—without which commercial electric lighting would be impossible; the use of safety fuses and of meters; and, the reason-for-being of the entire system, the high resistance incandescent lamp. That Edison's was the master hand, the guiding and forming spirit of all the work that went on in the seventies and early eighties, at Menlo Park and in New York, is told in the phrase of an old Edison man who said, "It was just as if he had the whole New York electric lighting system in his pocket."

More than a word of praise and gratitude, how-

ever, is surely due to all the men who, by adding their energy and patience to his, helped him to accomplish his dream. That many of these fellow-workers of his figure largely in electrical affairs in this country today, only proves Edison's gift of drawing around him people of uncommon ability.

Among the men now living who worked in various ways, prior to 1884, to bring about the Edison system, either in its experimental stages or in its introduction and early development, were: E H Johnson, one of Edison's lieutenants, who also had much to do with the introduction of the Edison system into England; Charles L Clarke, who had charge of the engineering affairs of the Edison Electric Light Company and the Edison Electric Illuminating Company, and who is now with the General Electric Company; S Bergmann, now influential in electric work in Berlin; Francis R Upton, for many years manager of the Edison Lamp Factory; Major S B Eaton, once president of the Edison Electric Light Company and of the Edison Illuminating Company; Samuel Insull, Edison's secretary in 1881 and manager of his business affairs for many years, now president of the Chicago Edison Company; John W Lieb, Jr, now vice-president of The New York Edison Company; W J Hammer, who is interesting himself in aviation; W S Andrews, now of the General Electric Company; T C Martin, secretary of the National Electric Light Association; F J Sprague, of motor and street railway fame; John W Howell, now technical engineer of the Lamp Works at Harrison; W S Howell, of

the Electrical Testing Laboratories; J H Vail, now in the electric automobile business; H S Campbell, superintendent of the second district of The New York Edison Company; Robert T Lozier of Kountz Brothers; Charles L Edgar, president of the Boston Edison Company; Charles S Bradley; Charles

DRAWING OF A PROPOSED EDISON CENTRAL STATION
Scribner's Magazine, February 1880

Wirt, at present engaged in electrical manufacture; Charles L Eidlitz; C E Chinnock, who is still busy in electrical work; W J Jenks of the General Electric Company; F S Hastings, one time secretary of the Edison Electric Light Company; H M Byllesby, who in 1881 was in the engineering department of the Edison Electric Light Company, now of the H M Byllesby Company; Ernest J Berggren, at the Edison Laboratories in Orange; A S

Huey, vice-president of the H M Byllesby Company; Dr E G Acheson, the inventor of Carborundum, whose factories are at Niagara Falls; Joseph Hutchinson, now interested in advancing the use of storage batteries in Canada; George Foster Peabody; James C Hipple, manager of the Lamp Works at Fort Wayne; Sydney B Payne, with the General Electric Company at Boston; M A Brock, now manager of the electric station at Paterson, New Jersey; Henry M Doubleday; William H Meadowcroft, assistant to Edison at the Edison Laboratories in Orange; W H Francis, now of the Boston Electric Company; John I Beggs; W E Freeman, assistant treasurer of The New York Edison Company; John F Ott, who has been with Edison forty-two years; Fred Ott, who has a record of only four years less; Peter Weber, formerly with Bergmann, now at the laboratories in Orange; Fred A Scheffler of the Babcock & Wilcox Company; J C Walker, the electrical engineer; John W Lawson; S D Mott; N K Iwadari, who took the first Edison lights to Japan; George G Grower; Montgomery Waddell; C F Hanington; Richard N Dyer, who for many years acted for Edison in patent matters; and Francis Jehl, who did much of the testing of early meters, now of the General Electric Company of Budapest.

Many other people have been associated with Edison, but they perhaps began their connection with him after work on the incandescent light had been completed, or left him before it was undertaken. Others, too, have died, chief among them

Charles Batchelor and John Kruesi, two of Edison's most trusted assistants.

The above list, for which completeness is not claimed, may serve as a citation of many of the men who had a hand in the beginning of Edison Service.

In connection with pioneer days of electric lighting, it is worth while to look for a moment at the keen interest in this new method of illumination, taken by people all over the world, and emphatically by Americans, even before the day of Edison's invention. For proof of this, it is only necessary to go through the files of any good periodical published between 1878 and 1882.

The reader of today will perhaps be astonished to find there many articles on electric lighting. In *Scribner's Magazine* for November 1878, is the statement: "Many students of its phenomena, have predicted that light from electricity would replace gas and oil."

This was not the first prophecy of its kind, of course, for in 1834 Professor Dumas of Paris foretold the ultimate success of the electric light. But by 1878 the average reader was so a-tip-toe for news of progress in this direction that scarcely a single number of a magazine went to press without some account of discovery or experiment in electric illumination. This eager desire was undoubtedly due to the successful use of the Jablochkoff "candles" in Paris. But people seemed to understand that no form of the arc lamp would be suitable for house lighting; and in America, at least, they turned to Edison to find a way out of the difficulty. Papers

and books were full of stories of Edison, of his inventions, and of the fact that he was working on the electric light.

In *Scribner's* of March 1879, is this note: "Attention has been called to the fact that a strip of metal or carbon enclosed in a glass jar charged with nitrogen and brought to incandescence by electric current will give a good light."

A CLUMSY PREDECESSOR OF THE MODERN DROP-LIGHT
Drawing of an Arc Lamp for a Table
Scribner's Magazine, November 1878

Then, late in 1879, all the world knew that Edison had perfected his incandescent lamp. But two years and more passed before it furnished actual proof of its practicability. This came with the opening of the Pearl Street central station and the use, shortly afterward, of 5000 incandescent bulbs in the Wall Street district.

Thus, Edison Service entered New York. That its welcome was skeptical, at first, is shown by the fact that current was supplied free to customers for nearly five months. But before that time was over it had become so indispensable that it has ever since grown with the metropolis and helped it to grow. And into every place this service has penetrated, it has brought the power to accomplish tasks more quickly, in better air, in cleaner

surroundings and with less danger. It has dug into the earth for subways, and helped to raise the huge arms which build skyscrapers; it has lessened the burden of sweatshop workers by providing them with a substitute for foot-power; it has lifted elevators; it has made streets safer and cleaner by reason of its light. Today, it is a basic element in the life of New York City, woven into the very fiber of the town's existence, so that people depend on it to help them carry on their business, their pleasures, their duties.

The Development of the Skyscraper

IN less than the lifetime of one generation, New York has been witness to a rare and wonderful thing—the birth and growth of a new architectural style. This is the skyscraper. Today it stands a huge and mighty symbol of the city whose demands brought it into being. That it is impressive, the most bitter of its opponents admit; that it is picturesque in its directness and force, artists with a vision of the future have already seen; for it typifies the limitless ambition, the unquenchable energy, the resourceful daring and the vast new wealth of a people.

It may be looked upon as the most radically new form of architecture brought into existence since the Gothic; for Renaissance was but a reworking of classic ideas. As the Gothic was the flowering of the spirit of the Middle Ages, so today, skyscrapers are the direct outgrowth of the life of a city, of the aims and occupations of its people, of conditions under which they work.

An inciting reason for the tall steel and stone structures of today, was, of course, the rise in value of land in lower Manhattan. And this, in turn, as every one knows, was due to narrowness of the island itself, which prevented the business center from spreading in any other direction than northward.

It is interesting to know that Edison, in building the Pearl Street central station, was obliged to reckon with this question of limited ground-room. He says:

"While planning for my first New York station—of course I had no real estate and, from lack of experience, had very little knowledge of its cost in New York; so I assumed a rather large, liberal amount of it to plan my station on. . . . In my original plan I had 200 by 200 feet. I thought that by going down on a slum street near the water-front I would get some pretty cheap property. So I picked out the worst dilapidated street there was, and I found that I could only get two buildings, each twenty-five feet front, one one hundred feet deep and the other eighty-five feet deep. I thought about $10,000 each would cover it, but when I got the price I found that they wanted $75,000 for one and $80,000 for the other. Then I was compelled to change my plans and go upward in the air where real estate was cheap. I cleared out the building entirely to the walls and built my station of structural ironwork, running it up high."

What Edison thus did in a small way in 1882, the city began to carry out in good earnest a few years later; for the first real skyscraper went up in 1888. This was the Tower Building at 50 Broadway. It was only eight stories high, but it possessed at least two indispensable characteristics,—skeleton construction and passenger elevators,—which made it the forerunner of the Metropolitan Tower, the Singer Building and the Woolworth Building.

THE FIRST SKYSCRAPER AND ITS TALLER NEIGHBORS
Drawn by Joseph Pennell

MANHATTAN BRIDGE IN COURSE OF CONSTRUCTION
Drawn by Joseph Pennell

Without skeleton construction, which implies technically, the use of a steel, wrought iron or cast iron framework, the erection of tall buildings could never have been made commercially advantageous; for a structure without such a frame would have walls of so great a thickness as to be prohibitive, owing to the amount of valuable ground-space lost. This is easily seen when it is realized that in the eighties, the New York building code required a wall to be not less than twelve inches thick for the highest fifty feet of the building, with an increase of several inches for each fifty feet between there and the ground. Of course the most serious loss of office room, under this system, would be on the lower floors, which command the highest rentals.

Forces, then, which have made the building of skyscrapers both possible and practical, may be set down as: skeleton construction; the passenger elevator and plate-glass; the use of electric power and light; and it may be interesting to touch somewhat on the development of each of these factors.

In 1880 the world had already passed through a period of great progress in bridge building of which the Brooklyn Bridge—then under way—was perhaps the crowning achievement. Engineers had had wide experience in dealing with structural iron, and the Bessemer process, followed by the Siemens-Martin method, had given them steel. This new metal had been found highly satisfactory, because of the fact that it is equally strong in tension and compression and also has no "grain." Its toughness and cheapness were in its favor, too, steel being little more expensive than cast iron; and, moreover, it is peculiarly adapted to beams and columns.

The principles which men had learned through work on bridges, they were ready to put to use in buildings. But one difficulty stood in the way; cast iron, wrought iron and steel are all affected by intense heat, and a building so constructed would warp under the influence of flames. In looking for a cure of this evil, the ordinary kitchen range was found to solve the problem. Made of iron, it is able to withstand a high temperature because its metal work is separated from the white hot coals by a brick lining.

Once grasped, the idea of surrounding the steel framework of a building with heat-resisting bricks

THE TERMINAL BUILDING

Drawn by Joseph Pennell

or tiles, was found to work perfectly; and, thereafter, it was possible to erect a structure at once tall, strong and fireproof, the walls of which need not exceed twenty inches in thickness.

It would have been of little avail, however, to put up such a building if human beings had been forced to climb numberless flights of stairs; but here elevators came to the rescue. The present-day swift passenger elevator is the direct descendant of an invention which Elisha G Otis exhibited in 1853, during the World's Fair at the Crystal Palace in New York. It was the first lifting arrangement in which provision was made for stopping the car if the cables should break. Then, in 1859, Otis introduced an independent reversible engine directly connected with the hoisting machinery; and in 1871 came the hydraulic elevator.

Now, hydraulic lifts and those run by steam power could answer the needs of buildings of moderate height, but both these types are ordinarily inadequate for making a rapid ascent of hundreds of feet. Consequently, the swift passenger service, which is so necessary in an extremely tall modern office building, remained, in general, to be accomplished by the electric elevator. Curiously enough, it was invented in the very same year which saw the erection of the first skyscraper. After that, though buildings grew and grew with an Alice-in-Wonderland rapidity, means were already at hand for making the trip to the fortieth floor quick as well as safe. This, in a city whose people are jealous of lost minutes, has done much to make "going up in the air" popular.

The extensive manufacture of plate-glass in this country, is another though less vital part of the success of high buildings. Such window glass as was used ordinarily in 1880, would scarcely have resisted the winds which whistle around the crests of Manhattan's brick and steel mountain peaks. At that time, however, there were in the United States only three plate-glass factories in operation, and their product, or its imported rival, was expensive. But in the following year, James B Ford opened his plate-glass works at Creighton, Pennsylvania, and thus began an era of prosperity and productiveness in that industry. In turn, plentifulness of plate-glass tended to raise the quality of ordinary window-panes partly by competition, partly by the introduction of natural gas methods of manufacture in both instances. Thus designers of towering structures were not hindered by having to search for a strong, clear substance with which to fill their windows. The introduction of wired glass, which will not splinter in case of fire and which admits more light to hallways and elevator shafts, is the latest improvement in this direction.

Finally, we come to another factor of prime importance in the making of skyscrapers: the use of electric light and power. By 1888, the year in which the Tower Building was erected, the New York public had become so converted to the incandescent lamp as to expect new buildings to be lit by it. For this reason the question of lighting a very high building with gas has never been seriously entered into. It could be done, undoubtedly, though gas

would prove a little more unwieldy in piping; but the demand of tenants has always been for electric light.

The connection of electricity with the skyscraper goes far deeper than the matter of light. Need for electric power to run passenger elevators if the service is to be swift and the height of the building is great, has already been mentioned. But the most fundamental help, literally speaking, which electric current gives the modern building is in the construction itself. It drives machines which bore for foundations; it moves hoists which lift girders into place; it operates concrete mixers; it supplies motive power for riveting. In short, the structure as it goes up is an outward and visible sign of electricity at work.

Leaving for a moment the question of what "juice" accomplishes in these ways, to take up the description later on, it is best, at this point, to trace in outline the progress of the skyscraper from the year 1888 up to the present.

In 1889–90 the New York World Building was erected and for a number of years it bore the distinction of being the tallest office structure known. Its sixteen stories were regarded as marvelous. In fact, in 1893, there was a very general belief that no architect would dare plan anything higher.

The number of stories began to increase, however, and with them, a sort of superstitious terror of skyscrapers. This is illustrated by a bit of gossip which went the rounds of New York in 1897. It was said that the American Tract Society Building swayed in the wind and that once—supposedly from this

WORK AT NIGHT ON A SKYSCRAPER
Drawn by Joseph Pennell

cause—a clock on the top floor had stopped! One is led strongly to suspect that somebody forgot to wind that clock. The report, however, was seriously denied in a magazine article; and an experiment afterward proved that in an eighty-mile-an-hour gale a skyscraper swayed about one quarter of an inch.

In 1898, some of the tallest edifices in New York were the Ivins Syndicate Building, twenty-eight stories high; the St Paul, with twenty-six stories; the Commercial Cable, of twenty; and the Manhattan Life, two stories shorter than the latter.

The "Singerhorn," as it has been picturesquely nicknamed, and the Metropolitan Tower, with their forty-odd floors, marked the next stages of the skyscraper's growth, while today Manhattan Island contains about seven hundred tall buildings. Of these, the present leader in height is the new fifty-five story Woolworth Building.

In the rise of this man-made mountain range, which has transformed New York into a commercial citadel, Edison Service has played a conspicuous part; for it furnishes the giant strength which goes to put together an enormous building with speed and accuracy.

The combined force of motors used for work on a single building sometimes amounts to a thousand horse-power or more.

Some of this energy goes to operate derricks for raising girders, the work being done by eighty and forty horse-power motors. Then, millions of bricks must be lifted to the floors where they are needed.

Forty and fifty horse-power motors run these hoists which resemble freight elevators. At the same time, the deafening process of riveting must go on. For this, motors drive the air-compressors which do the work. Often the labor goes on night and day, and the rapidly rising structure has to be wired for temporary lights, keeping several electricians busy. Cement and concrete mixing-machines, run by more motors, are installed in the basement, while electrically driven compressed-air chisels are used for carving the ornamental stonework.

This heavy equipment has its result in incredibly rapid work, so that today it is possible to erect a twenty-five-story building in twelve or fourteen months.

When it is remembered that great European cathedrals grew to completion in forty to a hundred years, it is easy to see that steel and electricity have made short-cuts for the architect.

The process of erecting a skyscraper begins with tearing down the old building. This contract usually covers shoring, sheath-piling and the laying of a temporary sidewalk. The owner of the building is insured against all liability for damage to passers-by. Drilling for foundations is the next step and electricity enters into it.

The rolling mills have perhaps half the work of building done by the time the substructure is completed. This, by the way, takes from four to six months. But the putting of the steel in place goes on quickly.

As soon as four or five stories of the framework

WEST STREET
Drawn by Joseph Pennell

are in place, the masonry is begun on the ground floor. When the roof is reached, plumbers are working in the basement and leaders have been set to carry off water from the roof, while an electrically driven pump is drawing away surface moisture from the cellar.

Next, the steel workers prepare elevator shafts and stairways, while plumbers and marble contractors are at work. The steam up-and-down pipes are placed and electricians lay tubing through the building, preparatory to wiring. Then come the plasterers, and, after that, the finishing strokes: painting, adjusting of elevators and the placing of electric fixtures.

When a skyscraper is completed and ready for occupancy, Edison Service begins its next undertaking, the making of this great structure a comfortable place in which to live. It lights offices and showrooms; it runs elevators; it drives pumps to lift the water supply to the topmost story; it draws in fresh air from out-of-doors; it seals documents; it adds columns of figures; it copies plans for architects; it supplies added oxygen to crowded rooms; it drives apparatus for the special work of the doctor, the dentist, the chemist; in fact, it performs whatever tasks man's ingenuity has taught it, for the greater comfort of the skyscraper's inhabitants.

THE SINGER BUILDING FROM BROOKLYN HEIGHTS
Drawn by Joseph Pennell

ALONG THE NEW YORK WATERFRONT
Drawn by Vernon Howe Bailey

Three Decades of Industrial Change

IN 1882 the use of electricity as motive power in factories and workshops was a dream of the future. Today it is an accomplished fact, tending steadily toward the increase and improvement of production, and toward the greater comfort and safety of workers. Its influence in this department of modern life is summed up in a recent article from the *Scientific American Supplement:* "Electricity," it states, "has become a mighty ruler in the realm of industry and trade. The concentration in the production of energy, simplicity of power transmission, and possibility of power distribution down to the smallest units have made possible this victorious career. . . . The present tendencies of specialization and production on a large scale in a series of successive stages have been promoted by electricity, while the reduction in the cost of operation, elimination of manual labor, improvement in the social and hygienic condition of all branches of industry have brought about more powerful developments than have ever been witnessed in so short a time in any field of human activity."

That Edison realized the efficacy of electricity as a power for driving machinery, is shown by the fact that he invented a motor before he had perfected the incandescent lamp. This was in 1879 while he was

EAST RIVER
From an etching by H Farber. *Harper's Weekly*, March 13 1880

working out his electric system. He had already designed his dynamo, and the motor was an adaptation of the same machine. Thus, when the Pearl Street central station began to supply with current its network of mains and feeders in 1882, the seed of industrial change was planted in New York soil.

About 1869 or 1870 Edison had perhaps his first dealings with a motor. It was not his, but the supposed invention of a man named Payne, as the story is told in the Edison biography. Payne alleged that he had perfected a device by which sawing could be done by electricity. He arranged for an exhibition of the machine at his Newark shop to Professor Morse, of telegraph fame, and General Lefferts, of the Gold and Stock Telegraph Company, who was anxious to invest money in this new marvel.

Fortunately, as it afterward turned out, General Lefferts decided to take along with him his young employee, Thomas A Edison, to look over the motor. This machine, weighing perhaps six hundred pounds, was of circular form and stood with the ends of several small magnets projecting through the floor. A belt connected it with a large circular saw. At the proper moment, Payne started his motor and the sawing began, the power generated astounding beholders because its source was two small cell batteries. But Edison had suspicions of something wrong. Putting his hand on the framework of the motor, he noticed that the latter shook slightly, in time to the puffing of a steam-engine across an alley. This explained the wonder of the machine, for it was really worked by the engine by means of a belt under the floor, one of the magnets being used to shift the power on and off, the others being purely ornamental! It was a dozen or so years after this, that genuine electric propulsion became practical.

In glancing back at industrial conditions in New York City in 1882, three facts stand out as fundamentally connected with the changes which were to follow. One of these has been mentioned—the absence of all electrical processes in manufacture. But the first step toward their introduction had already been taken in the beginning of Edison Service.

Another state of affairs which has a bearing on the electrification of workshops, is the fact that in 1882 no attention was paid by the general public to

factory conditions, the first law of this kind having been passed in 1886.

Lastly the immigration question, for New York City at least, had begun to assume its present proportions, for in 1880 the great annual influx from Europe had suddenly nearly tripled and had taken

THE NEW FARMERS' MARKET IN NEW YORK
From a sketch by C A Keetles. *Harper's Weekly*, January 10 1880

on a new character. Instead of being composed largely of Northern European races, it now had its source in Italy, Russia, Roumania and Austria-Hungary.

It is an interesting study to notice how the overcrowding of the city with strange peoples, and the lack of restraints as to their employment, brought about industrial conditions which today electricity is helping to remedy.

To begin at the beginning—if such a thing is pos-

sible in so complex a cosmopolis—the East Side had been a teeming, ill-supervised region long before the eighties. In 1817 and again in 1828 sudden rises in the number of immigrants had filled its old dwelling houses to overflowing. The practice of a whole family living in one or two rooms and sometimes taking boarders is not a recent one, it seems, for in 1834 Garritt Forbes, then city inspector of the Board of Health, called attention for the first time to the high death rate in this region. He blamed "mercenary landlords who only contrive in what manner they can stow the greatest number of human beings in the smallest space." New York had a population of 270,000 at that time.

In 1842 Dr John H Griscom made an inspection of the city, and he found that 1459 cellars were being used as residences by 7196 persons. After the publication of his report, citizens awoke to the need for some sort of supervision of tenement districts and efforts were made to better their condition. But the problem, large when first undertaken, kept growing, and the enforcement of regulations was a difficult matter.

In 1882 the laws of the city required that a cellar, to be rented as a residence, must have at least one foot of its height above ground and must be provided with one window. This would not seem to have been too stringent a demand, but it was somewhat modified by the agreement that if such a cellar had a windowless back room, leased in conjunction with the front room, the former apartment might be considered to be properly ventilated if it had a tran-

som. The New York which possessed this now obsolete law prided itself on having come a good way on the road to housing its poor properly.

Into the East Side, already thus overburdened with population, were swarming in the early eighties, hordes of aliens, mainly agricultural people, ignorant of our customs, separated from us by the barrier of strange speech. Small wonder that, afraid to push out into the open country of which they knew nothing, they preferred to huddle together in the maelstrom of a community busy with its own affairs.

Once settled in New York, they had to get work, and being mostly unskilled they could not command good wages. In this way, the factories and workrooms of the city found themselves always supplied with "hands" glad to get positions for small pay.

At the same time there was no law regulating hours of work, lighting, ventilation or the safeguarding of dangerous machinery. Any such legislation was looked upon as violating the citizen's right of contract, without taking into consideration the fact that these newly arrived Americans, poorly sheltered in their own dwellings and pressed by necessity, were in no position to judge or to speak for themselves in industrial matters.

Before long, however, people began to realize that the unrestricted work of women and children was not a question of individual willingness, but one of possible menace to the whole community. The first factory law in New York State was passed, accordingly, in 1886. It was called, "An act to regulate the employment of women and children in man-

THE GOAL OF THE IMMIGRANT
Lighted for the Hudson-Fulton Celebration

ufacturing establishments and to provide for the appointment of inspectors to enforce the same."

Following this, came demands for the adoption of safer machinery, for proper ventilation and sanitation, and for suitable adjustment of hours of labor. Men were beginning to see that ill-health, overwork and disaster affect not only the worker, but through him the whole body politic.

Just here electric power, which had all the while been quietly extending its usefulness, stepped in, promising to provide safety, accuracy, speed and comfort. Nor has it fallen short of this prediction, for wherever it has been tried it has been found to increase production as well as to lessen danger and disease.

It will be necessary now to go back a little and trace the growth of Edison Service in this direction. When the first central station opened, it supplied current for lighting only; but in the summer of 1884 electrically driven fans were introduced into a few downtown offices. It is said that those first motors lay unused on the shelves of the Pearl Street headquarters for several months before they were put into commission. So great was the success of the fans, however, that in the following summer there was a very considerable demand for them.

In 1888 several Pearl Street printing-offices arranged to have their presses run by electricity. This innovation was found most satisfactory, and from that time the Edison Electric Illuminating Company took up the supply of power as an important part of its business. A motor set up in the Hartfield

THE REMOVAL OF THE OBELISK FROM THE FOOT OF NINETY-SIXTH STREET
TO ITS SITE IN CENTRAL PARK

Leslie's Weekly, October 16 1880

Telegraphic Code Publishing Company at 73 Pearl Street in 1889 is still running, and its owner says it has cost him only $25 in repair bills during more than twenty-two years.

In 1889 the Illuminating Company supplied motors on its lines with current amounting to 470 horse-power. That was the first year that the motor load was sufficiently important to be included in the report of the board of trustees. The next year it was 697 horse-power and in 1891 there was a gain of 188 per cent, the record standing at 2000 horse-power.

In 1891, when the new station at Pearl and Elm Streets was building, the supplying of current to workrooms had become a question worthy of consideration; for the company's report in January of that year said: "The site in Pearl and Duane Streets near Elm . . . is central to the most important lighting districts of the city, being between the banking and general business districts to the south, the dry-goods district to the west, the important small factory district to the north, and the Bowery and Grand Street shop district to the east."

In 1890 a motor inspection bureau was organized to encourage the use of electric power by keeping such equipment in good order. Later—in 1897—this work was taken over by an outside firm.

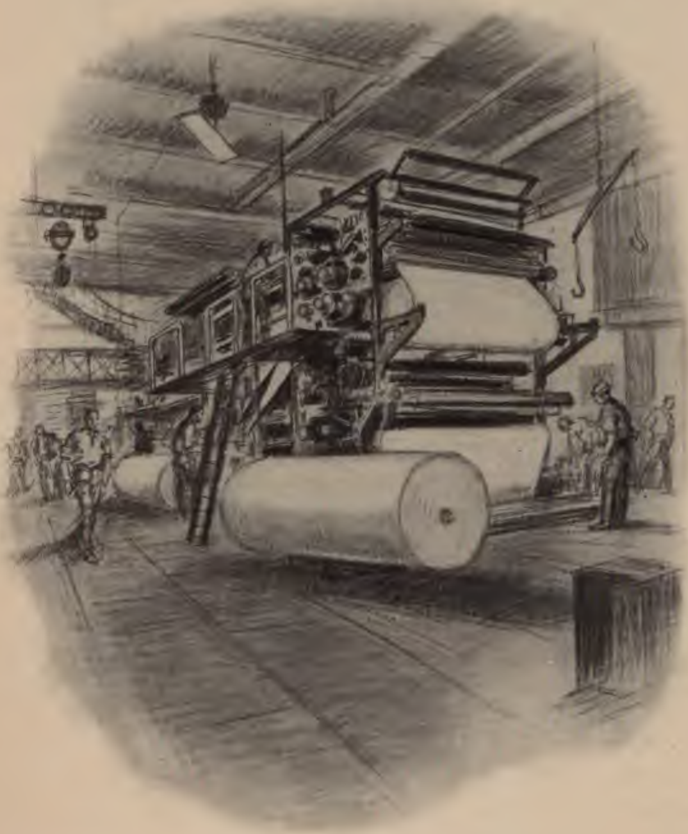
The growth of power supply in 1895 was marked. Forty-seven types of motors were installed, many of them being for the operation of ventilating fans, but even more for lifting elevators. Every year since then has seen a steady rise in the power load until now it is about six hundred times what is was in 1889.

These figures, of course, do not represent industrial development alone, since they include the supplying of current for elevators and also its consumption for electric attachments in homes and offices; but they may serve to show how great has become the demand for power.

That Edison Service contributes much to industries in New York at present is evidenced by the number and variety of trades which call upon it. As printing establishments were pioneers in the use of motor-driven machinery, so today, newspaper offices are among the largest consumers of power. These buildings may not be looked upon as factories by the outsider, yet their enormous presses and their bustling composing-rooms entitle them to be so ranked. Besides setting presses in motion, electricity operates the melting-pots of linotype machines, burns away superfluous felting in the "forms," lights composing-rooms, stereotyping departments and city rooms. Central station service supplies the *World,* the *Times,* the *Sun,* the *American and Journal,* the *Press,* the *Evening Post,* the *Globe* and the *Morning Telegraph,* thus doing much to hand New Yorkers their matutinal newssheets. It is perhaps equally useful in the realms of magazine and book publishing.

It also turns wheels and drives implements for machine-shops, clothing makers and confectioners, while it kneads bread for bakers and cuts stone. Besides this, it grinds spices and is used in box factories, textile works and refrigerating plants.

The feasibility of connecting single tools or ma-

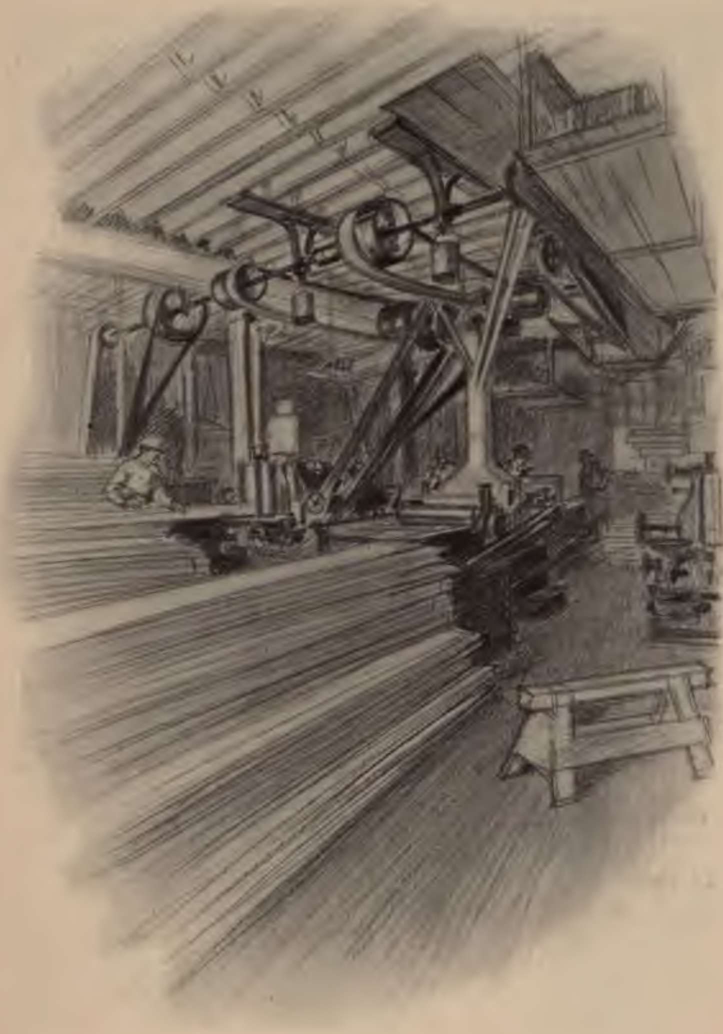


A NEWSPAPER PRESS-ROOM
Drawn by Vernon Howe Bailey

chines directly with their source of power, has had much to do with the growing use of the motor drive. This principle of the direct-connected unit, first put into practice in traveling cranes, was seen to be so effective that it has since been adapted to all kinds of implements, large and small, reducing serious delays in case of breakdown and economizing current.

Loft buildings, which are going up on the locations of many old factories, are practically all wired for Edison current, and this holds true for new manufactories of every sort. The convenience of central station service, together with its added safety and comfort, are some of the reasons for its wide-spread popularity. Add to this the fact that it is peculiarly needed in a city where land values are so high that each owner cannot spare room for a generating plant, and it becomes clear that such a system is an economic necessity.

Moreover, electric motive power is in demand by the producers themselves. When the striking New York garment workers went back to their shops, one of their stipulations was that all the machinery they used should be run by electricity. Their reasons were that engines are noisy, that overhead belting is a collector of dust and a danger, that the use of foot power is exhausting and sometimes crippling. This feeling among garment workers is rapidly bringing central station supply into the various small factory districts of the city, where its presence is improving conditions in that industry as well as in others.



SHAFTS AND BELTING IN A FACTORY

Drawn by Vernon Howe Bailey

BUILDING THE SKYSCRAPER
Drawn by E Horter

Another recognition of the advantages of electric power in trades is its very general use in Manhattan vocational schools and courses. Not long ago an educator stated that all students in these classes should be taught the management of electrically driven implements, because only in this way could they be prepared for the more desirable positions and work in the most favorable environments. Besides, this teacher urged, as electricity is coming to be more and more generally relied upon in manufacturing processes, it is the duty of schools to graduate pupils experienced in the new methods. The New York Vocational School for Boys, it may be added, has its entire mechanical equipment supplied with current.

Thus, electricity is lightening drudgery in the great task of furnishing the world with goods, and it is accomplishing this to the advantage of the merchant, the worker and the consumer.

As to the further possibilities of this transformation, they cannot be better stated than by quoting again from Dr Siegel's review of the question in the *Scientific American Supplement:* "Wherever electricity has been adopted there has been increased safety and efficiency, with . . . a substitution of mechanical labor for human and animal muscular work. There is thus an increasing spiritualization of labor which, commenced by the steam-engine, has been promoted more and more by electricity, and we must expect this tendency to extend even farther in the future."

A Revolution in Housework

THE same thirty years which have seen the rising tide of change sweep over commercial and industrial New York, have been marked by a quiet, but none the less steady, alteration in the mechanism of the home. For the spirit of an age works in every direction and all departments of living move in parallels, interacting, more or less, upon each other. As an instance of this, it may be observed that while the skyscraper has been springing up in the lower half of Manhattan, its mate, the apartment-house, has gained ascendancy over the northern part of the island and the Bronx. The coming of this multiple domicile is, in itself, an interesting leaf from the history of New York, and serves, besides, as a commentary on various stages of home life in the city.

In 1882 "flats" were already numerous and popular, while the handsome elevator apartment-house had been accepted as a suitable residence for fashionable folk.

In the *Sun* of September 4 that year, the very day on which the Pearl Street station was opened, appeared an editorial entitled: *A Great Change in New York.* "The work of changing New York from a city of private, individual dwelling houses into one of tenements, each inhabited by a large

number of families, is now going on more rapidly than ever. It will not take many years to make this city resemble Paris in that respect. A comparatively small number of people will have houses to themselves. . . . The great mass of the population, poor and well-to-do, will be crowded in tenements."

The article went on to hail this innovation as an improvement on the conditions of living then prevalent. For land had become so valuable that it was impossible for a man of moderate or small means to own or rent a private house in a good residence district, and this had forced many people to take up a boarding-house existence. But the advent of buildings subdivided into independent groups of rooms, held out an opportunity for the resumption of family life, without which no community is happy or prosperous.

The first apartments in New York were opened in 1865, having been arranged in a remodeled club-house at Fifteenth Street and Fifth Avenue. Although they were small and very expensive, they had all been leased before work on them was completed. Within a few years, several other buildings of the same sort were begun, and during the twelve months of 1873 about two hundred apartment-houses were built.

Before this period, men who did not want to move their families into boarding-houses and who would not bring up their children in tenements, had resorted to the practice of leasing substantial "brown-stone fronts" at rentals far beyond what they could afford. Then, to recoup, they sublet portions of

RIVERSIDE DRIVE
Drawn by Vernon Howe Bailey

their homes, or perhaps their wives took table-boarders. There was, of course, in this arrangement the uncertainty of finding tenants and the constant worry of making ends meet; but it enabled a man to live in a good street and to keep up that *sine qua non* of New York existence—"appearances."

For these people, the apartment-house looked like a haven of refuge. However, before long, the very demand for such accommodations had raised their price, and owners began to say that land values were so high as to make low rents out of the question. Still, the problem of how to live was ameliorated if not solved, for a degree of privacy and unity had been secured to the family, and a great step had been taken toward the simplification of housework. Running expenses in the home were lessened, and the servant question was made to assume smaller proportions by reducing the necessary drudgery. That the new domesticity had some drawbacks no one denied, but it was the only practical compromise with the exigencies of living in New York City. Today, after thirty years of development, its only rival is the great suburban exodus. And that has been made possible largely by electric traction; but—as Kipling says—"That is another story."

In 1882, then, the average New York home—outside of the tenements—was either a three-story-and-basement house, twenty feet or so wide and exactly like its neighbors, or an apartment whose size, decorations and comforts depended on the purse of its temporary possessor. It might have windowless bedrooms and be perched at the top of four flights

THE MALL, CENTRAL PARK

Nueva York Ilustrada, 1886

A SKATING PARTY ON CENTRAL PARK LAKE
Drawn by A B Frost. *Harper's Weekly*, February 28 1880

of stairs, or it might command the services of a much-buttoned elevator boy and a view of Central Park.

As to general internal aspect, the home varied according to taste. But, though the era of crocheted antimacassars on chairs and conch-shells on mantelpieces was waning, mid-Victorian black walnut furniture was much in use. This horror of unnecessary bulges, being too substantial to wear out and too expensive deliberately to be thrown away, continued to protrude bunches of grapes into the backs of unwary callers and to offer the marble tops of its tables for the repose of the ubiquitous photograph album.

The Centennial Exposition at Philadelphia a few years earlier, however, had already awakened better and simpler taste in interior decoration. There, thousands of Americans had beheld the Eastlake

house from England. They had seen the beauty and straightforwardness of William Morris's furniture, to which we owe the present "Mission" styles. They had had arranged for them good examples of Elizabethan work, of colonial mahogany, of Italian renaissance, of sturdy Queen Anne tendencies. They had been able, even, to compare genuine Louis XV lightness with the perverted rococo carvings and jig-saw work which it had inspired. And many a woman had gone away from the exhibition secretly determined to carry out in her own rooms the effects she had noticed.

Her efforts in this direction were not always successful and often resulted in a conglomeration of plush parlor sets, easels, spinning-wheels, and dried cat-tails. Who shall write of the agony of soul of the woman who, having learned better, was obliged to go on living for years with the red velvet sofa and chairs which she had purchased in the days of her ignorance? But, through mistakes and disappointments, she was discovering—it was generally "she" because "he" was ingrossed in business—the value of simplicity and sincerity in surroundings.

This, in the eighties, was the leaven already working, which would result in the present taste for dignified, well-made furniture, reposeful colors and intelligent treatment of line and mass in household decoration. It had much still to accomplish, for the curse of grooves and twists was upon even the woodwork and cornices of every house; so that thirty years have scarcely sufficed to induce lumber mills to turn out smooth, plain moldings,

while preposterous carvings still adorn certain grades of furniture. Reverting to the year 1882, and ceasing to look upon the home from an esthetic standpoint, the work of making it attractive, clean and comfortable, of cooking meals and washing dishes, was then a laborious hand process.

Spring-cleaning, for instance, raged in varying degrees in every household. In some, where foresight was aided by the presence of many workers, it was merely a period of some little discomfort and interruption; but for others it was a yearly horror, to be conducted by the conscientious, hardworking housewife and to be shared by every member of the family. Taking up the carpets began it, or rather, preparations for taking them up; and, hardwood floors being little used, this meant the upheaval of almost every room in the house one after another. Bookcases were emptied of their contents and the books, carefully dusted, were placed in clothes-baskets to await the restoration of the room, while all

AT MANHATTAN BEACH
Nueva York Ilustrada, 1886

CHARMS OF BRIGHTON BEACH IN THE EIGHTIES
Nueva York Ilustrada, 1886

other heavy furniture was removed. Carpets were next rolled up and carried into the back yard for beating, or, if their owner lived in a flat, sent away to be cleaned. Closets and cupboards having been overhauled, pictures were taken down from all the walls, wiped and stored temporarily in other rooms. About this time a terrible odor of soap and wet floors pervaded the establishment. Then came the night when a cold dinner was served in the kitchen to save trouble. An unpleasant effort to maintain a pleasant atmosphere during the meal generally accompanied this ceremony. After that, little by little, things began to go back into their places and within a few days, members of the family were able to resume their routine of life, to rest and rub their strained muscles with arnica.

Housecleaning brings us naturally to the item of the rubbish barrel. At that time it might be made the receptacle of anything—ashes, cats or discarded lace curtains. Nor was it required that fire-preventing, metal ash-cans be used, or that a cover be placed on the garbage pail. Municipal housekeeping, in its relation both to the household and to public health, has made a decided advance since then. At present, ashes, rubbish and garbage must be carefully separated and placed in prescribed containers, this doing much to facilitate their safe and economical disposal.

To go back to housework itself, few if any modern aids to cooking were in use at that time, though it should not be forgotten that the word "modern" is relative, and that the coal range, with its connected

hot-water supply, had been accepted as a wonderfully up-to-date labor-saving device not very many years before. But the idea of making toast at the breakfast table or of keeping the meal hot and ready overnight in a fireless cooker, would have been regarded as fantastic.

The washing by hand of clothes and dishes were heavy monotonous tasks, far from inviting, even when the worker was provided with plenty of hot water and stationary tubs. And ironing day, in hot weather, rounded out this nineteenth century ordeal by fire and water. A roaring blaze had to be kept up, the use even of gas for this purpose being still a thing of the future; and the whole house sweltered.

In the early eighties, then, household duties were performed by hand, at the expense of strength, en-

CHRISTMAS AT THE FIVE POINTS HOUSE OF INDUSTRY
Drawn by W T Smedley. *Harper's Weekly*, January 10 1880

THE PASSING OF THE BROWNSTONE FRONT
Drawn by Vernon Howe Bailey

ergy and patience; but this doing them was accepted as a matter of course, for no other way had yet been discovered.

The year 1882, however, marks the beginning of a new era in housework, for Edison's electric light and power system, put into effect that September, had been planned by its inventor to meet the needs not only of the office but also of the home. It was destined to play as great a part in the revolution of home industries as in the change of business and factory conditions, but its application here has not been a sudden affair; rather a matter of slow, steady, quiet growth.

To realize the far-reaching influence which electricity is having on domestic affairs today, it is only necessary to look into the life of a New York household. This typical family probably lives in an apartment. If it is lucky, it does not approach its Lares and Penates afoot but is lifted thither by an electrically driven elevator.

In the suite which makes this family's home, Edison Service supplies light, thereby doing away with smoked ceilings and the scattering of burnt matches. And to electric lighting is due the now commonly accepted luxury of snapping a switch as one enters a room, instead of fumbling in the dark to find the light.

The annual housecleaning volcano is quiescent if not extinct, for electric power stands always ready to operate the vacuum cleaner. Walls and floors can be kept immaculate, cleaner than the most exacting housekeeper of a few years ago demanded; while

the same instrument draws dust out of upholstered furniture, mattresses and heavy hangings.

By the help of electric current, the weekly ironing is made quicker and simpler. Moreover, this aid is always available for the pressing which accompanies the dressmaker's invasion, while the same current runs the sewing-machine.

Then, in the dining-room, the electric chafing-dish and tea-kettle invite an impromptu after-theatre supper. In the morning, the late-comer to breakfast may prepare his own fresh toast in a jiffy, without rumpling the feelings of the cook. But even should the latter leave, the housewife might perhaps put roast, vegetables and pudding for the night's dinner into an electric automatic cooker, turn on the current for a few minutes, turn it off again, and go out for the day. And the contingency of having to do the family washing need not disturb her, for current, by turning a crank, can simplify this also.

Thus central station service enters into household life, but the limits of its possibilities have not yet been reached. Every year sees the perfection of new electrical devices for making home pleasant; a better place for the servant; a better place for the woman who does her own work; an organism which responds more quickly to the needs of all who live within its walls. And this is only another way of saying that Edison Service is bringing to the home, no less than to the skyscraper and the workshop, greater comfort in living, greater ease in working, cleaner and more healthful surroundings.

THE METROPOLITAN TOWER

The twenty minutes' exposure necessary for taking this picture is recorded in the movement of the lighted clock hand

Thirty Years' Growth within the Company

IN tracing the development of a large organization it is simplest to begin with the more general facts and work from them to ways, means and details. Accordingly, an outline of the growth of the Edison central station system in New York City will be followed by somewhat more particular descriptions of equipment, methods and management. In this treatment, The New York Edison Company and the Edison Electric Illuminating Company, of which it is the successor, will be considered as practically one body, since the service which they have fostered has been continuous and unchanged in guiding principles.

As a fitting opening to this story of growth in electricity supply, it may be interesting to make a few surface comparisons. When the Pearl Street central station opened in 1882 it had fifty-nine customers, while today it supplies 159,000 meters. Then, its mains and feeders measured less than fifteen miles. Now the underground system which it inaugurated amounts to 1350 miles. At first, the territory served was a single square mile in lower Manhattan, but thirty years have seen it extend until it covers all the island—nearly twenty-two times the original area—

besides the Bronx with its more than forty square miles.

A still greater rate of increase has taken place in the load sustained and in the generating system which furnishes the necessary current. In September 1882, 1284 lamps had been installed for customers, only 400 of these being actually lit on the fourth of that month, while the name "Jumbo" was given in marveling admiration to the dynamos in the Pearl Street station because each of them could feed 1750 sixteen candle-power lights. Today 5,215,000 incandescent lamps derive their glow from Edison current, to say nothing of the fact that this central station system at present supplies an aggregate installation of 10,704,900 fifty-watt equivalents. In 1911, a single steam turbine capable of developing 30,000 horse-power commenced its career at the Waterside station, being the rightful heir to the 125 horse-power generating units so much talked of twenty-nine years earlier.

Having cited these few instances as barometers of progress, it will be best to return to the early days of Edison Service and to follow its advancement year by year.

The report of the Edison Electric Light Company for 1881 tells of the organization of the Edison Electric Illuminating Company. It should be remembered that the former body was the holder of all Edison's patents on the subject of electric lighting. "New York City was selected as the place where the light should be first introduced on a large scale," read the report. "Originally your Board intended

IN NEW YORK'S OLD BUSINESS DISTRICT
Drawn by Vernon Howe Bailey

to have this Company itself light up an initial or model station in this city. That plan was changed because it was found that under the laws of the State the use of the streets could be obtained only by a Company organized under the Gas Statutes. Consequently a new Company, known as the Edison Electric Illuminating Company for New York, was formed to install the first model station. Accordingly a contract between that Company and the Light Company was executed under date of March 23 1881."

It is, perhaps, worth while to speak here of other central station plants which had their inception at nearly the same time. On April 25 1882, the Western Edison Light Company was licensed for the states of Illinois, Iowa and Wisconsin, as well as a similar company for California and Nevada. That same year a central station system was preparing in Santiago, Chile, though it was meeting with some little difficulty in obtaining a right of way through that city's streets. Central stations were being planned for Lawrence and Fall River, Massachusetts; Covington, Kentucky; and Williamsport, Pennsylvania. There was also the probability of licensing a company to light Jersey City, Hoboken, Rutherford Park, Passaic and Paterson, while a small plant was already in operation at Appleton, Wisconsin. This, indeed, preceded the Pearl Street opening by a few weeks, having begun its service on August 15 as the first commercial station in the United States. It was, however, small in capacity, for its one dynamo could supply only 280 ten

LOWER NEW YORK AT TWILIGHT

From the eastern tower of the Brooklyn Bridge

candle-power lamps. The Holborn Viaduct system in London was really the first demonstration of incandescent illumination in a large city. It began its work on January 12 1882 and furnished current for 3000 lights. Unfortunately, the Electric Lighting Act of that year so restricted the new industry in England as to discourage its further development.

At the First District station in New York, the last few months of 1882 were spent in making various minor changes and improvements—these, however, not being allowed to interfere with the current—and in wiring for more lamps. The service to all customers was free, for Edison wished to make thorough observations before entering into contracts to supply light. On October 1 1882 the company had fifty-nine customers. A month later it had ninety-four, and on the first of December, 203; while it had installed 5328 lamps of which 3144 were in use. At the commencement of 1883 there were 231 patrons of central station service, and in February the company began to charge for current. It was a month or two later before the system of regular monthly meter records and bill collection was in full force.

A partial list of some of the more prominent users of the lights in April 1883, includes:

Peabody & Co; Fisk & Hatch; Continental Bank; Vermilye & Co; Third National Bank; Winslow, Lanier & Co; John H Meeker; James Leach; Union Building; Max Jacoby; Alexander Agar; A S Barnes & Co; Samuel Raynor & Co; William Tate & Co; Lehn & Fink; Morris Tasker & Co; Washburne & Moen Co; Ansonia Brass & Copper Co;

Creque, Reynolds & Co; Richard Koll; Wadsworth, Martinez & Longman; P W Engs & Sons; McCoy & Labrie; Drexel, Morgan & Co; Commercial Union Assurance Co; United States Assay Office; Great Western Insurance Co; H & C L Despard; National Fire Insurance Co; Knickerbocker Insurance Co; Howard Insurance Co; New York Insurance Co; Chase & Higginson; Post, Martin & Co; Sondheim, Alsberg & Co; Parke, Davis & Co; Shannon Miller & Crane; Motley & Sterling; W C Duyckinck; Edward Barr; Moore & Warren; Dingfelder & Libko; Hanlon & Goodman; H B Kirk & Co; Silleck & Co; Mark Mayer; E Goldbacher; D Jacobs; S Bowman; F W Devoe & Co; Kueffel & Esser; Marshall Lefferts; New York News Co; McGowan & Slipper; New York *Times; Truth;* F N Burke & Co; Seabury & Johnson; Pancoast & Rogers; New Haven Steamboat Co; D H Houghtaling & Co; Manhattan Railroad Co; E Blackford.

The popularity of the new light continued to grow so that on the first of the following September—about a year after the opening of the district station—there were 455 consumers of its current and 11,192 lamps had been installed, though only 8218 of these were in actual use. But in spite of the fact that incandescent lighting was steadily gaining ground, the company discovered at the end of the year that it had lost $4457.50. In 1884, however, it found itself with a profit of $35,554.49.

It was during the summer of that year that motor-

OLD GREENWICH VILLAGE

Drawn by Vernon Howe Bailey

driven fans were first introduced, and at the same time another step forward was taken. Owing to imperfect electrical determinations in the construction of the district, lamp breakages had at first been numerous. But the inequality of pressure having been for the most part corrected, and the lamps themselves having been improved, their hours of life had begun to lengthen. The average of 400 hours in January 1884 had been increased to 914 hours by November, and by December of the next year this had risen to 1347 hours. It is curious to notice how important in the beginning was this question, for the durability of the lamps seemed to measure the success which the new lighting system was achieving.

In 1884 two more dynamos were added to the Pearl Street equipment, and the superintendent of the station reported that there were over one hundred applications on file which could not be accepted because the plant was already taxed to its utmost capacity.

The following year, and the first of Mr Spencer Trask's presidency, the company found itself in excellent financial condition, without debts of any kind except a mortgage of $30,000 on the station buildings. Accordingly, dividends at the rate of 4 per cent per year were declared, and the first quarterly payment was made in August. The possibility of opening another district to extend from Twenty-third Street to Central Park and from Eighth Avenue to Madison was much talked of. It was urged that this uptown region, including most of the

theatres, hotels and clubs of the city, would burn lights for longer hours than the business district, where many of the buildings closed at six in the evening. Moreover, Edison's then recent "three-wire" patent would materially reduce the initial cost of such a system.

An annex station for the First District was instituted in 1886, a plant of 2000 lights' capacity being set up in the cellar at 60 Liberty Street. This was done in order to answer a pressing demand for service. Meanwhile a constant endeavor had been made still further to prolong the life of lamps, thereby cutting down expenses for renewals. By the end of the year, lamps were being made to give an average of 1462 hours' use.

The plans for a new district were held back at this time because it was impossible to secure permits to open the streets. Mr Spencer Trask, as president of the board of directors, alluded to the difficulty in his annual report:

"All attempts in this direction have been blocked by an Electrical Subway Commission, so-called, created by the New York Legislature for the ostensible purpose of putting existing overhead telegraph and other wires underground. . . . So far as all other electric lighting companies were concerned, this did not work any great hardship, as they neither had nor have any underground system of their own, and are therefore more than satisfied to continue their existing pole-lines. But with us the case is different; we have never stretched a foot of wire above ground; we possess a practical system of

"NEW YORK IN A FEW YEARS FROM NOW: VIEW FROM THE BAY"
A cartoon by Thomas Nast
Harper's Weekly, August 27 1881

underground conductors which has successfully stood five years' uninterrupted use, and all that we ask is that we be allowed to use this same underground system up-town. One would think that a commission created to place wires underground would readily grant such a request; but no, the answer has been substantially that we must wait till the trench is built, and then come into it and submit to tribute!"

Late in the summer of 1887 permits were obtained for opening a few streets in the new second and third districts which were to extend from Eighteenth Street to Forty-fifth Street, and other permits followed. Accordingly, on Thanksgiving Day 1888, the Thirty-ninth Street station began to supply current, and on Christmas the one at Twenty-sixth Street was put into commission. These two buildings were fully equipped fireproof generating plants. There were twenty-eight dynamos in the Twenty-sixth Street station, each having a capacity of 600 amperes. All of the underground system in the two new districts was laid according to the new three-wire patent, and it was announced that customers would be supplied with motive power as well as with light. In the spring of 1889 the first low-tension arc lamps were connected with the uptown system.

On the morning of January 2 1890, came the fire which destroyed the original Pearl Street station and which has been described in more detail elsewhere. The company did not lose a single customer through the short impairment of service which this disaster occasioned.

Six months later the site of the present Duane–Pearl Street building was purchased from the estate of A T Stewart, and plans were commenced which were to lead eventually to the new building's becoming the source of current for the entire First District. Work was rushed on the new plant, the structure being carried up only to the top of the second story where a tile flooring formed a secure tem-

porary roof. In this way, it was not long before machinery could be installed, and current was turned on May 1 1891.

Previous to the first of October 1890, current had been furnished at a cheaper rate uptown than downtown, the price in the former district being 1.1 cents per sixteen candle-power lamp-hour, while it was 1.2 cents in the latter. Thereafter, however, the price was fixed at one cent per sixteen candle-power lamp-hour all over the city.

During 1891 much of the old two-wire system in the First District was converted into the three-wire type, and the several districts were interconnected so that the entire Edison system from Bowling Green to Fifty-ninth Street was continuous. It was at this time also, that, a water famine threatening New York, the company drove several deep wells to insure an uninterrupted supply, thereby discovering that the Duane Street building was in the best spot in the city for obtaining artesian water.

In the summer of 1892 the wiring department was given up and its business transferred to the New York Electric Equipment Company, Limited. This was in accordance with the policy of the company to devote itself to the question of supplying current without conducting auxiliary business enterprises. Early that fall the company was asked by the city to arrange for lighting Fifth Avenue during the Columbus celebration. All overhead wires were banished from that street by municipal decree, and the company was faced with the problem of providing street arc-lights under these conditions. A new

LIGHT AND SHADE ON THE EAST RIVER

twin-arc system was evolved and, by the first of October, Fifth Avenue was ready for illumination by a method only thought of a few weeks before.

The Edison Company, having now been ten years in existence, found itself the largest local electric illuminating organization in the world, supplying a total installation 50 per cent larger than that in the city of Berlin, its nearest rival. Its net earnings for that year were $475,137.61 and its customers numbered 4344; while it supplied current to 142,492 incandescent lamps, 1637 arc-lights, and had a power load of 3807 horse-power. Its underground mains and feeders amounted to 165.22 miles of three-wire system and 6.57 miles of the old two-wire. That year the Fifty-third Street station was opened though its structure was not completed. A part of its equipment was a Crompton-Howell (English) storage battery, the first application in this country of a storage battery in a low-tension generating station.

"Hard times" in 1893 reduced the amount of current consumed by each customer, but the large number of new installations more than counterbalanced this. The Duane-Pearl Street building was nearly finished that year and in its designing, just as in the company's other stations, electrical forms were adhered to, giving individuality to the structure.

In 1895 the original Pearl Street central station was dismantled and sold, while a new building was erected at 115–117–119 East Twelfth Street. Two 300 horse-power De Laval turbo-generators were ordered from France, after careful study of the advantages of turbines. These steam turbines

were the first to be operated in an electric lighting station in this country.

The following year the Produce Exchange generating plant was replaced by a storage battery annex in the Bowling Green building and an experimental station was opened at Seventy-second Street and Fifth Avenue. Here, high-tension current received from the Manhattan Electric Lighting Company, Limited—in which Edison stock-holders now had an interest—was transformed by motor generators into low-tension continuous current for distribution. That the experiment was successful, the after history of the company shows. During the spring of the same year an electrical exposition was held in the city, at which the company's exhibits attracted wide attention, especially in the matter of cooking and heating possibilities. As a result, an electric kitchen was put into operation at the Duane Street office for the inspection of the general public.

Large increase of business marked the next two years. In 1898 an alternating-current equipment was introduced at the Duane Street plant, and high-tension transmission to the Thirty-ninth Street station was begun on November 3. Four rotary converters and six static transformers had been placed in the latter building and current at high tension could be sent in either direction, this being one of the pioneer applications of rotary converters in connection with a high-tension transmission system. At about the same time a distributing annex was built at 200 Elm Street, and the temporary Seventy-second Street converting and distributing plant was

A GALA NIGHT IN CITY HALL PARK—JULY 4, 1911

replaced by a permanent one at 123 East Eighty-third Street.

That year the company's wires ran beneath the surface of the city in a continuous chain through the central part of Manhattan up to Ninety-sixth Street. There were 239.7 miles of this underground system, supplying 9990 customers.

For some time there had been talk of building a waterside generating plant. Land had been purchased and tentative plans had been made, but it was thought best to make investigations abroad before launching the project. Accordingly, in the summer of 1898, an engineering commission consisting of Mr John W Lieb, Jr, then general manager of the company, Mr John Van Vleck then its engineer of construction, and Mr Arthur Williams the general inspector, visited the chief electrical stations of Europe and consulted experts. In 1901 these plans were modified and finally completed under charge of Mr Thomas E Murray, and, early in 1902, the first Waterside station was opened, occupying the block bounded by First Avenue, Thirty-eighth and Thirty-ninth Streets, and the East River. The operating room contained sixteen vertical engines, each with a capacity of 5200–5500 horse-power, at most economical rating, from which current at 6600 volts, three-phase, twenty-five cycle was generated by 3500 kilowatt generators and sent out to numerous distributing centers.

At the beginning of 1902 the company had 420 miles of underground system supplying installations amounting to 1,928,090 fifty-watt equivalents. The

Bronx district—after two years of existence—was developing rapidly.

In 1904 four steam generating plants were in use besides the big Waterside station. These auxiliaries were at Duane Street, Twelfth Street, Twenty-sixth Street and One Hundred and Fortieth Street at Rider Avenue, while current was supplied to more than a dozen substations.

In 1906 "Waterside No 2" was built, with its capacity of 103,000 kilowatts. It occupied the block just north of the first structure and was so arranged that, while independent of its neighbor, the two plants could be operated jointly, thereby dividing the load at any time or working together, as might seem most desirable.

The establishment of these two stations marks at present the last important step in the company's history, since by them concentration of the generating process is accomplished. Production of electrical energy is now confined to the Waterside plants except for infrequent assistance from Duane Street or from the Bronx station at hours of greatest demand during the winter months. Accordingly, this realization of the plan conceived more than a dozen years ago, closes a review of the stages through which New York's great central station system has developed, until today it supplies more than half the current used in Manhattan Island, and employs more than 5000 people.

WATERSIDE ILLUMINATED FOR THE HUDSON-FULTON CELEBRATION

The Generating System

IN considering the manufacture of electric current for Edison Service during the thirty years of its existence, this work will be seen to have gone through four successive stages. In the first of these, direct current at low voltage was supplied to one district only and was generated at the original Pearl Street station. Though an auxiliary plant was established during this period in the cellar of 60 Liberty Street, it was not a complete generating station, and therefore need not demand serious attention. The second stage may be said to cover the years when the Edison Electric Illuminating Company maintained several distinct and complete steam generating plants, furnishing low-tension current throughout a much more extended region. The beginning of high-tension transmission ushered in a third period of development, during which both high-tension and low-tension current were produced, according to needs, at a few district stations. The fourth and present stage has seen the concentration of the manufacturing process at Waterside and the complete adoption of high-tension transmission combined with low-tension distribution. These phases will be dealt with in the order of their growth.

257 Pearl Street—the first Edison central station

in New York City—had been purchased, together with 255, in May 1881, by the Edison Electric Illuminating Company. Of the iron substructures originally planned for both buildings, only the one for 257 was ever put in place, since its neighbor was converted into a storage and repair-shop. The girders ordered for the latter half of the property remained to the credit of the company for years and were finally used in the Pearl–Duane Street station. Since the buildings had been erected for commercial purposes, they could not have sustained the weight of engines and dynamos. Accordingly, the heavy skeleton construction, introduced into 257, was erected so as to be independent of the outside walls. It occupied the full width of the building and about three quarters of its depth, but did not in the least affect its external appearance.

The vault under the sidewalk and the basement in the front of the building were fitted out with machines for the receipt of coal and the removal of ashes. An engine of twenty horse-power, by means of countershafting, drove the screw conveyor for carrying the coal up over the boilers, whence it was dropped by gravity to the stoke-hole on the basement level between the boilers, and also the screw conveyor for taking ashes from beneath the grates and discharging them into a barrel under the sidewalk. These screw conveyors were forerunners of present elaborate arrangements for mechanical coal-handling, by which this process is made practically automatic. The engine also operated a fan blower, delivering forced draft to the furnace and supplying

air for ventilating the stoke-hole. A system of blast-pipes was also provided for blowing air to the armatures of the dynamos.

Four Babcock & Wilcox boilers, with a rating of 240 horse-power each, discharged their products of combustion into two steel stacks, one at each end of the building, and they supplied steam to the engines through an 8-inch header with 5-inch vertical branches. These boilers had cast-iron headers, and as an evidence of the life of this class of apparatus it may be of interest to note that from the time this station was put into service, September 4 1882, until March 31 1894, they were in constant service under very severe conditions. They were then removed and placed in the Fifty-third Street station, where they continued their usefulness until May 22 1902, having seen nearly twenty years of hard service.

A gallery extended over the boilers and gave access to the stoke-hole and the basement in the rear of the building, where a "Z" dynamo of sixty-light capacity was installed, which furnished light during construction, and from which current was taken for the first tests of the underground system.

The boilers were provided with injectors, supplemented by a steam-pump with connections to each boiler, the water being previously passed through exhaust heaters located in the rear of the building.

The original engine equipment consisted of six Porter-Allen engines, each of 125 horse-power (nominal) with cylinders 11$\frac{3}{16}$ by 16 inches, steam pressure 120 pounds, 350 revolutions per minute, giving a

WATERSIDE
From a painting by Guy C Wiggins

piston speed of 933 feet per minute. These engines weighed approximately 6450 pounds each, or with dynamo and base-plate a total of 61,550 pounds each, and were subsequently replaced by an equal number of Armington & Sims engines, 14½ by 13 inches, at 350 revolutions per minute.

The six dynamos were of the Edison "Jumbo" type. Here it might be mentioned that Edison's first "Jumbo" was sent to the Paris International Exposition in 1881. The next two were installed in the Holborn Viaduct station at London in January and April 1882.

The style of "Jumbo" used in the Pearl Street station was described by Mr C L Dean, superintendent of the Edison machine works, as follows:

"Attached to each dynamo and mounted on the same bed-plate, so that it forms an integral part of the steam dynamo, is a steam-engine of 125 horse-power and capable of being driven up to 200 horse-power. Each of these dynamos has already developed by actual test 1750 lamps of sixteen candle-power each.

"Weight of the various parts:

Bed-plates	10,337
Zinc bases	677
Fields	16,372
Cores	6,044
Keepers	6,300
Pillow blocks	671
Rocker arms	125
Armature	13,310
Engine	6,500
Total weight	60,336 pounds"

The field-magnet had twelve cores, 57 inches long, of which the four in the top row were 8 inches and the other eight were 9 inches. They were wound with four layers of No 12 BWG copper wire. The resistance of the coil on each of the 8-inch cores was about 2.8 ohms, and on the 9-inch cores 3.1 ohms. The field poles were 49 inches long and 28¼ inches inside diameter. The armature, mounted on a 7¾-inch shaft, had a core 12½ inches inside diameter, 26$\frac{7}{16}$ outside diameter, and 46½ inches long. The armature winding consisted of ninety-eight copper bars on the armature-face, and the same number of connecting copper end-disks. The bars had an average length of 55¼ inches, and were 0.721 inch wide on their top face, 0.69 inch wide on their bottom face, and 0.484 inch deep. The end-disks were 0.102 inch thick. The capacity of the machine when cooled with air-blast was about 850 amperes under about 115 to 120 volts electro-motive force at the machine terminals, or practically a capacity to operate 1200 103-volt lamps, with extra voltage capacity to compensate for drop of electro-motive force in the conductors between the machine and lamps.

The tenth *Bulletin* of the company, published June 5 1882, contained the following statement regarding one of the generating units:

"The magnetic field of this machine is produced by sixteen electro-magnet arms joined to two pole pieces, and their coils are traversed by a current derived from the main circuit. The dimensions of this machine as it is now constructed, are as follows:

THE METROPOLITAN AND MADISON SQUARE TOWERS

Drawn by Louis Fancher

Resistance of armature circuit is 0.0037 ohm, and that of the electro-magnet circuit is 6.7 ohms. The armature has 106 copper bars and its core has 2200 thin sheet-iron disks; 125 horse-power is used in driving the armature which makes 350 rotations per minute. The current has 110 volts tension and can supply 1200 sixteen candle-power Edison lamps. The weight of the machine is thirty tons."

The dynamo room was provided with a traveling crane and hoists, running the entire length of the building to facilitate installation and repairs. The engines were non-condensing and exhausted into the atmosphere through exhaust feed-water heaters. The engine dynamo units were arranged in lines parallel to the sides of the building, three units on each side. The main bus-bars of the station, made up of double half-round copper bars from No 1 two-wire Edison tubes, were attached to the wall along the sides of the building, with a connection between them across the ceiling. The dynamos were connected to them by flexible cables spanning the distance between the upright copper rods attached to the dynamo brush-holder arms and the wall. One of the copper uprights was provided with safety-catch holders, but solid copper links supplied the other connection.

The Edison tube feeders entered the Pearl Street end of the building, and were connected to the bus-bars by copper arms carrying safety-catches.

There was a set of auxiliary bus-bars above the main bus, leading to the lamp bank on an upper floor, and connected to one pole of the dynamo ahead of the switch; and on the other pole to the

corresponding pole of the main bus. This enabled the dynamo to be operated on the lamp bank for testing, or for giving the engine a load before closing the main switch connecting the dynamos in parallel on the main bus. This main switch, or circuit-breaker as it was called, was one of the earliest types of knife switches with contact in series, and had a previously unheard of capacity. It was operated by throwing the weight of the body on a long handle pivoted at one end, and released by heavy steel springs held by a trip pawl.

In front of the main contacts, and carried by the switch handle, was an auxiliary blade—the field circuit contact—making contact before the main line contacts engaged, and breaking after the main circuit was broken. This field switch was supplemented by a plug switch attached to the wall and connected to a field circuit bus-bar running the length of the station, with an auxiliary break through a lamp resistance to furnish a by-path for the field discharge.

The dynamo fields were controlled on an upper floor by moving simultaneously, through a horizontal shaft and bevel gearing, a number of horizontal contact arms over contacts connected with copper wire resistances wound on wooden frames.

It may now be interesting to state that when this pioneer station was started, and in fact for some little time afterward, there was not a single electrical instrument in the whole station—not a single voltmeter or ammeter! There was also a total absence of a central switchboard, as each dynamo had its

WATERSIDE
Drawn by Vernon Howe Bailey

control switches located at the dynamo. The feeder connections were concentrated at the front of the building, and the voltage control was on the floor above. The pressure was regulated from an automatic indicator, consisting of an electro-magnet connected across the main circuit, and whose pull was opposed by a heavy spring. The armature of the magnet carried a contact which engaged two relay contacts, on the high side connecting with a relay circuit to a red lamp, and on the low side, with a circuit to a blue lamp. At normal pressure neither lamp was lighted, but if the electro-

motive force rose one to two volts above a predetermined amount the red lamp was lighted, and the attendant at the hand-wheel of the field regulator inserted resistance in the field circuit. If the blue lamp was lighted, resistance was cut out until the pressure was raised to normal. The station was equipped with several of these indicators which were carried every few days to the Edison machine works at Goerck Street to be adjusted by comparison with a Thompson reflecting galvanometer and battery of standard Daniell's cells. Later on, this primitive indicator was supplanted by the "Bradley bridge"—a crude form of the Howell pressure indicators in use for many years in Edison stations.

On one of the upper floors of the station building was the meter room, where plates of the Edison chemical meter were prepared and weighed.

An article written some months before the station was started concluded with the verdict: "This electric lighting station is very complete in all its appointments. Every imaginable emergency has been provided for: coal-bunkers in the top of the building to hold a reserve of coal; water-tanks to supply water, in case of any deficiency or cessation of supply; thorough protection against fire, and thorough workmanship everywhere."

It is interesting, however, to turn away for a moment from a consideration of the mechanical equipment, to glance at the human side of conditions in this first plant. An old Edison man laughingly remarked the other day, "That old station was no dream!"

While there was neither jack-shaft nor belt to keep the air humming there were the sobbing and heaving of the pumps, the rush and clatter of the high speed engines within, and the puffing of locomotives on the elevated structure in the narrow street without. Clouds of steam, smoke and hot cinders blew through the open windows to increase, if possible, an all-pervading, ever-present heat—grease and vapor-laden—that was more enervating than the tropics. Everything was hot. Heat radiated from the smoke-stacks, and from the steam-pipes; from the engine cylinders; from all the bearing boxes, upon which ice had to be kept constantly to prevent the babbitt from running; from the armatures and the field coils of the over-loaded dynamos; even from the brushes which had to be set in a trough of mercury on the brush-holder studs to increase their conductivity; from the conductors from machines to bus-bars; and from the primitive switching lever by which one pole of the feeders was connected to the bus-bars. Heat rolled in great waves from the ill-ventilated boiler room and spread along the passage that led to the inadequate, hand-to-mouth coal storage pocket with its bare one day's capacity, and, rising, penetrated to the remotest parts of the station. Those men who operated the old Pearl Street station from the beginning to the very end—August 28 1894—fairly earned all the glory that will ever be given them.

"Jumbo" No 9, which stood nearest the Pearl Street front of the building, was the one which sup-

A MISTY MORNING
Drawn by Joseph Pennell

plied current on September 4 1882. On a certain Sunday not long after that, owing to the growing demand for current, Edison decided to put a second dynamo into commission. Immediately the two machines began to "hunt." Much thought had been given to the need of close regulation, with a view to maintaining steady pressure on lamps; but it was found that the governor on the type of engine selected was so extremely sensitive that each engine connected to the bus-bars made the most frantic efforts to take all the load. Daily, the engine room was the scene of greatest confusion in the efforts of the engineer to curb the would-be runaways and bring them into unison. That is, the device that was purposely selected to secure the conditions desired, was in itself the cause of variations that were too great to be long tolerated. Three of the engines were finally rejected, being replaced by those of the Armington & Sims make, whose governors were of a sluggish type which "stayed put" on all ordinary occasions.

Before leaving the discussion of the original New York central station it should be added that its use of direct-connected units was unique, the practice being neglected after that for some ten years, though it has since become the standard equipment for all important power stations. Besides this fact, one other should be mentioned. The cellar annex opened at 60 Liberty Street in 1886 did not manufacture its own steam, but contracted for it from the New York Steam Heating Company.

A second period in the history of the Edison

generating system began with the opening of stations at 117–119 West Thirty-ninth Street and at 47–49–51 West Twenty-sixth Street in 1888. These—the first buildings erected by the Illuminating Company for its purposes—were carefully planned to meet requirements of the new industry, and an accurate description of them appeared in the *Electrical World* for January 15 1889. Since they were twins, exactly alike in detail, the following extracts from this article apply to them both:

"Engines:—On each side of the building are located seven engines, making a total of 2800 horse-power when working under normal conditions. These engines are of the Armington & Sims type. They are built in accordance with special specifications furnished by the chief engineer, and are extra heavy, and very substantial in all the details of their construction. The cylinder of each engine is 18½ inches diameter by 18 inches stroke of piston, and the speed is 200 revolutions per minute. There are two driving-wheels, each of which is 86 inches in diameter by 16 inches face. The weight of each wheel is not less than 4500 pounds. Each engine is provided with an Armington & Sims automatic regulator, and develops 200 horse-power, cut off at one quarter stroke, under pressure of 90 pounds, at the throttle. Each engine is fitted with a large automatic sight-feed cylinder oiler, which, for extra security, is reinforced by an oil-pump that can be used in case of emergency. The guides, and all other working parts, are provided with drop sight-feed oilers of ample capacity. A system of oil channels

has been carefully laid out, which drains all the oil from each engine into a channel from which it is led off to be filtered for future service. Each engine is mounted on a cast-iron foundation box filled in with concrete. . . .

"Dynamos:—On the first floor of the building are located the dynamos. These are twenty-eight in number, of an entirely new type and construction, and are of larger capacity than anything heretofore built, with the exception of the celebrated 'steam dynamo,' which was constructed early in the development of the Edison business. Each of these dynamos has a capacity of 600 amperes and an initial electro-motive force of 140 volts. They weigh about 15,000 pounds each. The speed of the armature is 650 revolutions per minute. Two dynamos are driven by each engine. Fourteen of these dynamos are, as already intimated, to be located in a double row on each side of the building.

"The central space of the dynamo room is equipped with the necessary electrical appliances in the way of automatic feeder equalizers, individual ampere-meters for each dynamo, main ampere-meters for different divisions of the underground system, volt-meters for indicating the electrical pressure throughout the different portions of the district, and such other minor appliances as are required for the proper operation and control of the system. These are all conveniently arranged for rapid manipulation and economy in time and labor, and give absolute control of the electrical pressure and quantity of current. All the electrical apparatus, excepting

pressure indicators, was manufactured by Bergman & Co, and is the finest outfit in material and workmanship ever placed in an electric light station.

"An important feature of all Edison central stations is the margin above their rated capacity. That is seen in the present instance. Although these stations are each rated at a nominal capacity of 35,000 lamps, as stated above, great care has been taken to have ample reserve in all the generating apparatus. Any one of these stations can be called upon for an excess of 25 per cent above its rated capacity, and would respond so generously that not a single part would be subjected to undue straining."

These two stations were of the vertical type, every effort being made to save floor space.

The Duane–Pearl Street building was the next generating plant opened. It began to supply current in May 1891, and was planned to contain ten 2500 horse-power engines, each with a pair of 800 kilowatt dynamos; two 1250 horse-power engines, each with a pair of 400 kilowatt dynamos; and two 600 horse-power engines, each with a pair of 200 kilowatt dynamos. The engines were of the multi-expansion, inverted cylinder, marine type developed by Mr John Van Vleck, chief electrician and consulting engineer of the company, and were known as Van Vleck Disconnective Engines. By placing the steam chests on the front instead of between the cylinders, the engines were made 30 per cent shorter than previous styles, and by coupling them with direct-driven dynamos, these units were made to occupy only about one tenth the floor space required

for electric generating under former conditions. The dynamos just mentioned were of the then new multipolar type, built by the Edison works at Schenectady.

In 1892 arrangements were made with the Crompton-Howell Storage Battery Company, Limited, of London, to install a storage battery in the new Fifty-third Street station. It was to have a capacity of 2000 ampere hours and a guarantee of 85 per cent efficiency in this output. The success of this experiment has had a far-reaching effect upon the Edison system.

During this stage of the company's development it built, besides the Duane Street plant and the Fifty-third Street building already mentioned, the one in West Twelfth Street. This last was known as a horizontal station since great economy of floor space had not been sought after in its arrangement.

In 1892 the downtown district reached its maximum load on December 15. This amounted to 21,000 amperes or 45,000 sixteen candle-power equivalents. On December 14 the uptown district had its maximum load, an output of 20,320 amperes or 44,000 sixteen candle-power equivalents. The heaviest load on the entire system that year was 40,755 amperes on December 15.

In 1896 the opening of an experimental station at Seventy-second Street and Fifth Avenue ushered in the practice of high-tension transmission, and so marks an important point in the history of the Edison generating process. This led in November 1898, to the adoption of high-tension transmission

A NIGHT SCENE FROM METROPOLITAN TOWER DURING THE HUDSON-FULTON CELEBRATION

Brooklyn Water Tower and Institute Building seen in the background

between the Duane Street and the Thirty-ninth Street stations. They were connected by a high-tension cable through existing ducts under Broadway, and converting apparatus was installed at both ends. Direct current, taken from the Edison bus-bars at the usual voltage, might be converted from direct current to three-phase current at eighty volts by rotary converters, raised to high tension by static transformers, and transmitted through the cable to static transformers at the receiving end.

This stage of progress in the generating system was really a transition period, for, by 1898, tentative plans were already under way for building a great Waterside plant. These plans, with certain modifications, were finally developed under the direction of Mr Thomas E Murray, then vice-president and general manager of the company, and when, in October 1901, the first Waterside station was completed, the ideal of concentrating the generating processes was on its way to realization. The station was opened with one 3500 kilowatt engine; but after eleven of these had been installed, the equipment was completed with turbines in sizes ranging from 5000 to 9000 kilowatts each.

High-tension polyphase transmission, in combination with rotaries or motor generators, made Waterside technically possible; but it should not be forgotten that the help of storage batteries did much toward rendering it commercially successful.

The main operating room of "Waterside No 1" is 115 feet wide, 267 feet 10 inches long, and nearly 125 feet high. On the south side are five galleries

devoted to the offices, shop and store-rooms of the plant; on the westerly side, four stories high, inclosed in glass, are the electrical operating galleries.

Sixty-eight feet above the floor are tracks supporting two traveling cranes, one having a lifting capacity of fifty, the other of twenty-five tons, and both, a span of ninety-eight feet. In addition to their main hoists, each crane is equipped with a whip hoist of five tons. These cranes travel, fully loaded, at a speed of 150 feet, and lightly loaded, 200 feet, a minute. The hoist speed, fully loaded, is twenty-five, and lightly loaded forty feet a minute.

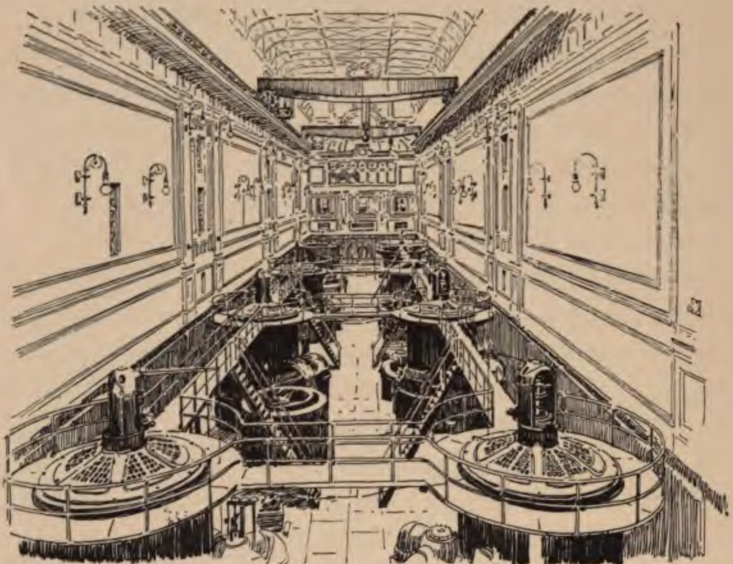
In the basement under the operating room are condensers and their auxiliary apparatus. Two standard batteries, one for the local district service, the other insuring constant potential on the field excitation bus, occupy a section extending the length of the building on the Thirty-eighth Street side. The oil-filters and pumps are also in the basement. Below the level of the basement floor are the condensing tunnels leading to and from the East River.

The controlling, indicating and recording features of the electrical equipment of the station are confined to a series of galleries occupying the entire westerly end of the structure. On the main floor are the motor-driven exciters, their switchboards, and the controlling and indicating devices for the supply, control and record of low-tension direct current distributed locally from this station. The rheostats of the exciter sets are on a mezzanine gallery directly beneath.

On the first gallery are the automatic oil switches controlling the feeders, and the transformers for the operation of their indicating and recording instruments. The main oil switches controlling the generators are also on this gallery. On the gallery above, the second, are the group selector switches controlling groups of two feeders, by which any group may be placed on either of the busses of the station, and the field rheostats of the generators.

The gallery above, the third, is the main operating gallery of the station. At the rear is the bus house, above which are the generator selector switches, by which any generator may be placed on either of the station busses. At the front of the gallery, so arranged that the operator faces and has in full view the machinery of the station, are the various switches, and indicating and recording instruments incidental to and essential for the operation of the generators. Each generator is controlled from a pedestal upon which are mounted the controlling switches and apparatus, directly above which is a vertical panel containing all the instruments relating to the generator. The instruments on each generator panel consist of a recording wattmeter, giving a summation of the output of the generator; a voltmeter, two ampere-meters, an indicating wattmeter, a field ammeter, a power factor indicator, a synchronizing lamp and the signal lamp connected to the overload relay. There are also illuminated signals by which orders are transmitted from the operator on the gallery to the engineer in charge, or vice versa.

Station No 1 has a rated capacity of 157,000 kilowatts and station No 2, of 140,000 kilowatts, the maximum load for the two stations in 1911 being 170,000 kilowatts. To carry on the work of these great factories for electricity, 700 men are employed.



THE OPERATING ROOM AT WATERSIDE NO 2

From a pen-and-ink sketch by Vernon Howe Bailey

THE SOLDIERS' AND SAILORS' MONUMENT LIGHTED TO WELCOME THE FLEET—1912

Technique of Distribution

AFTER current has been generated, the next step is the sending of it out into channels through which it will ultimately reach the consumer. Those channels are: first, the cables carrying it at high tension to substations; second, these stations, themselves, whose province it is to transform the high-tension alternating current into direct current at low voltage; third, the feeders and mains, by means of which "juice" is conveyed to points where customers desire to convert it into light, heat or power. Under the topic of distribution, then, will come the high-tension cables, the substations and the low-tension distribution network.

From Waterside two or more cables go out by different underground routes to each distributing station. In some instances the number of cables is greater than two, as for example, at the Duane–Pearl Street station where there are four cables, and at Twenty-sixth Street which has five, each connected with Waterside by independent routes. There is also a general tie-feeder which either loops or "tees" into all the stations and substations from Duane to One Hundred and Twenty-fourth Street. This feeder may also be used to transmit high-tension current from one converting point to another, independently of the Waterside station. The high-ten-

sion transmission system also extends into the generating station of the Metropolitan Street Railway Company at Ninety-sixth Street, and across the Brooklyn Bridge to the plants of the Edison Company of that borough.

Each high-tension feeder begins practically at the automatic oil switches on the first floor of the operating gallery of the Waterside station. Before this point is reached each pair of feeders is controlled by non-automatic oil selector switches, located on the second floor of the gallery. The selector switch permits the connection of the feeder on either of the two main busses of the station. The control of the oil switches of each feeder is concentrated on a feeder panel situated on the third floor of the operating gallery, upon which are also mounted the various indicating and recording instruments belonging to the feeder. Likewise, for the terminals of the feeders at the converting stations, there are feeder panels, upon which suitable switches have been placed for their control at that point.

Rubber insulation was used for the first of the high-tension transmission cables, but in more recent work paper has been adopted exclusively. The specifications for these cables were drawn to insure the best utilization of the subway ducts, and called for three conductors, each aggregating 250,000 circular mils and made up of thirty-seven strands of copper wire. The paper insulation is $\frac{5}{32}$ of an inch around each conductor, and the outside insulating jacket is of the same thickness. The lead covering is $\frac{4}{32}$ of an inch in thickness, and alloyed with from

NIGHT ALONG THE RIVER FRONT

White lines mark the paths of passing boats

2 to 3 per cent of tin. The open spaces between the conductors are filled with dry jute, saturated with an insulating compound to exclude air and moisture. It is required that after being laid in the subway, the insulation of the cable, including the joints, shall be 300 meghoms per mile at 60° Fahrenheit. In accordance with the rules of the Subway Company, each feeder is subjected to weekly tests. The capacity of each feeder is 250 amperes for each of the three phases at 6600 volts.

The subway system, which has been developed by separate corporations, extends through every important section of Manhattan Island. It consists of iron pipe or vitrified clay ducts, in groups of from two to thirty ducts, from two and five tenths to four inches in diameter, buried in concrete. Manholes are provided at each street intersection, the distance apart being about 250 feet. On trunk lines, passing through long cross blocks, the intermediate lengths may be a little in excess of this distance. Hand-holes serve the same purposes where the subway has more limited capacity. All cable joints are made in either manholes or hand-holes, where they may be easily cut for testing or repairs. The manholes are built of brick enclosed with double iron covers—the inner being locked—ventilated to prevent the accumulation of gas. Where passing through the manholes, the cables are carefully racked on iron hooks fastened to the walls. Those belonging to the high-tension system are covered with a wrapping of asbestos and galvanized steel tape, which affords protection from mechanical as well as electrical in-

A SUBSTATION
Drawn by Norman Price

jury, otherwise possible in the event of short circuit upon other cables.

Extending from Waterside there are four independent routes of trunk subways, each containing from twenty to thirty ducts so that accident in one, however remote, by no chance can extend to the others. In the high-tension transmission system at the present time there are 384 miles of cable carrying current at 6600 volts, three-phase, twenty-five cycles.

By means of this polyphase transmission, current produced at Waterside is brought to thirty-odd substations, located according to necessity throughout Manhattan and the Bronx. While there is some difference in the internal arrangement of these various stations their equipment is more or less similar. As a rule, cable vaults are located in the basement, with rotaries and low-tension switchboards, including control of the battery end cell switches, on the first floor. Static transformers, induction regulators and high-tension switches are usually on a mezzanine gallery with the batteries on the floor above. In some cases these last adjuncts are placed in the basement, while both low and high-tension switchboards occupy the mezzanine.

Besides rotary converters and storage batteries, a substation is usually furnished with air-cooled static transformers, induction regulators for the rotaries, a "booster" set for the batteries and a direct-current compensator for the three-wire system. The switchboard is generally divided into panels with devices for high-tension feeder control, low-tension feeder

control, rotary converter control, battery control, indicating, recording and synchronizing instruments and main and auxiliary busses.

Entering the station, the three-phase, 6600-volt, twenty-five-cycle, alternating current is received upon high-tension feeder oil switches. From these connections are made, through selector oil switches, with the high-tension busses. The rotaries are equipped with similar switches, so arranged that they may be connected to any feeder. From the machine high-tension oil switches, the current passes over triplex cables to the high-tension or primary coils of the static transformers. At the statics the alternating current is transformed in the secondary windings to 170 volts. The secondary sides of the transformers are connected, through the induction regulators, with the alternating-current collector rings of the rotaries. From the direct-current side of the rotaries the path leads directly to the low-tension switchboard, where suitable switches provide connection with any one of three busses, each maintained at a different pressure, supplying the low-tension, direct-current feeders.

On the direct-current side the normal pressure of the rotary converters is 270 volts, which may be raised or lowered thirty volts by the induction regulators. Any tendency toward unbalance on the three-wire system, which provides 120–240 volts at the services, is cared for by the battery and compensator.

All static transformers are air cooled and stand in sets of 3–200, 3–400, and 3–800 kilowatts respec-

tively for the 500, 1000 and 2000 kilowatt converters. They are mounted on a platform containing an air-duct for ventilation, in which, supplied by electric blowers from beneath or at the ends, air pressure is maintained at one half or three quarters of an ounce. The static transformers are wound for a ratio of transformation of 6300 to 170 volts. The latter types contain a thermometer, placed in the casing between the transformer cells, thus giving temperature indications.

Without undue heating, the transformers will operate at 25 per cent overload for three hours, or 50 per cent overload for one hour, after a twenty-four hour run at full load. The efficiency of the 400 kilowatt type is 98 per cent, and the regulation is 1 per cent. The use of electrically operated alternating-current switches on the transformer switchboard, controlled by small switches from the operating switchboard, results in shortening heavy cables and saving space on the operating board.

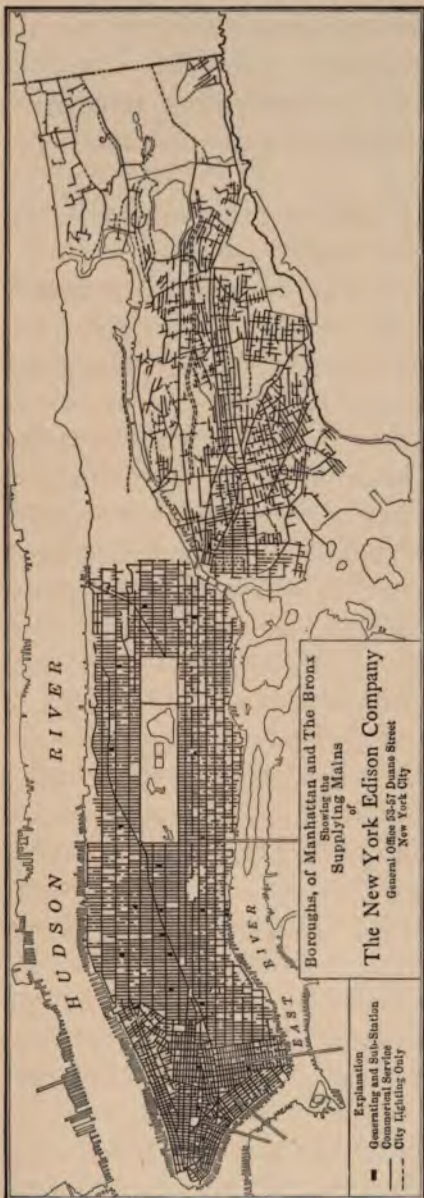
Induction regulators permit a variation of from 150 to 190 volts in the pressure of the alternating current at the rotaries. Their secondary windings are connected between the secondary side of the transformers and the collector rings of the rotaries. Their primary coils are wound on a rotor which, by means of a small direct current or induction motor, controlled from the operating switchboard, can be turned through a given angle in either direction. These regulators have a capacity of sixty-five kilowatts for rotaries of 400 kilowatts, and of 130 kilowatts for 1000 kilowatt rotaries. Standing upon the

same platform, they are cooled from air-ducts supplying the static transformers.

Rotaries now used in the company's substations are six-phase, 500, 1000, 2000 and 2500 kilowatts, respectively.

At present, however, five new 3500 kilowatt rotary converters are being put into commission. Their advantage is that they occupy less floor space per kilowatt. The rotaries convert to 240–300 volts direct current and their speed is 375 revolutions per minute for the 500 kilowatt type; 187.5 for the 1000 kilowatt converter, and 115 for the 2000 kilowatt size. A few 500 kilowatt rotaries, converting to 240–340 volts direct current, are used in the upper section of the city where long feeders are sometimes still necessary. They are provided with induction regulators of 130 kilowatts capacity, which give them this unusual range of pressure.

Recent standard storage battery equipment used by the company consists of chloride accumulators, each cell containing twenty-nine plates and being capable of discharging 500 amperes for eight hours, 748 amperes for five hours, 1120 amperes for three hours or 2240 amperes for one hour. The plates are contained in wooden, lead-lined tanks, 48 inches high, 21 inches long and 34 inches wide. They contain 754 pounds of acid and, including the acid, the weight of each completed cell or tank is 2492 pounds. There are 150 cells in each battery, seventy-five on the positive and a like number on the negative side. Twenty cells on each side are connected to the end cell switches.



When "juice," having been transformed in a substation to low-voltage direct current, is sent out into the conductors, it enters the underground network of low-tension feeders and mains, of which today there are about 930 miles in The New York Edison Company's system. Of these, 646 miles are mains and 319 miles are feeders.

Of the old Edison tubes, laid before the days of ducts, there remain about 200 miles. These are kept in good order, but in all new work cable is used exclusively both for feeders and mains. The Bronx district which, on account

of sparse population was originally designed to adhere to the Edison "village plan," has overhead wires. These, however, are being done away with, and it is intended eventually to give this region also an underground system.

In feeders, the outside conductors of Edison tubing —those of positive and negative polarity—have a maximum size of 1,000,000 circular mils, the neutral conductor having about one third this area. For other than tie purposes between stations, these feeders rarely exceed a length of one mile, for this is, under usual conditions, about the greatest distance of economical supply at a pressure of 240 volts. The cable feeders are concentric, two-conductor, one for each polarity. The neutrals are contained in independent cables of 2,000,000 circular mils, following the "tree" method, each being common to a number of feeders, thus providing at any given point very much larger conducting capacity in the event of serious disturbance in the balance of the system.

All single conductor cable mains are stranded, and each conductor has an area of 200,000 circular mils. In special instances, where the main acts as a tie between important points or where a large installation is to be served, larger sizes—350,000 circular mils and over—are used. Some single buildings require as many as four services, each having an area of 1,000,000 circular mils, or one inch cross section. In such instances, several feeders converge nearby on the local network, which is tied and strengthened in every possible way.

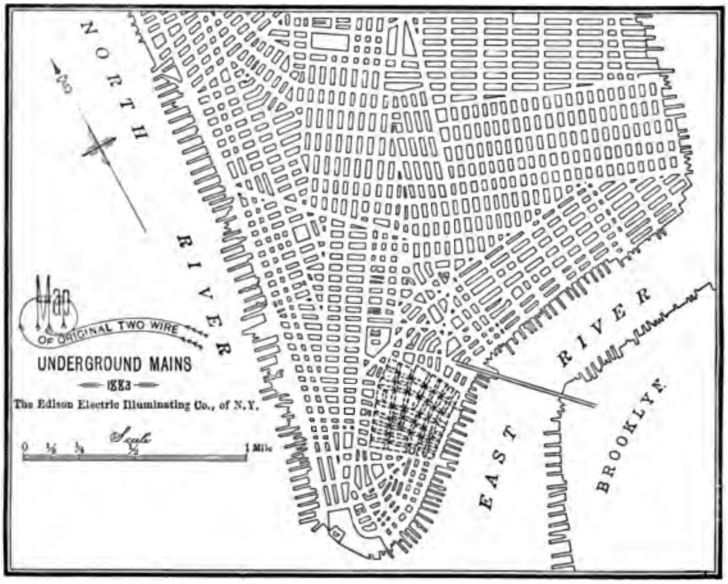
In all instances, services are brought into the

building to be supplied, at the expense of the company. They terminate on or near the front wall in a switch, by which the entire supply may be controlled. Fusible safety devices are installed at this point to cut off the current instantaneously should trouble develop on wiring, fixtures or apparatus. In usual practice the meter is placed near the service end, in a position insuring dryness and freedom from vibration, and otherwise favorable for the accurate measurement of current.

As the Edison tubes are supplied in lengths of about twenty feet—the width of a city lot—they are adapted to the convenient installation of an independent service connection for each building. The iron pipe and tile duct systems have hand-holes placed in the branch lines, accessible from the street by removing an iron cover, from which building connections may be conveniently made.

An important feature of the Edison underground system is the junction-box, of heavy cast iron, circular in form, with tube stubs at the bottom; the number, and whether for mains or feeders, being determined by the type of the box. It is enclosed with heavy iron covers, the inside one tightly bolted down on a rubber gasket, thus making the interior water and air-tight. The other lies loose on a suitable flange for the purpose of protecting the inner cover, maintaining the street level and supporting traffic. In the interior of the box are heavy copper rings, one for each polarity, which connect by flexible cables with conductors contained in the stubs to which, in turn, mains and feeders radi-

ating from the box are connected. All conductors make common connection with these rings, the positive and negative, through safety fuses, which, in the event of overload arising from accident or other cause, melt and sever the defective part from the general system. The neutral series of conductors is continuous without safety fuses, and is carefully grounded at each box. Thus the entire system of mains and feeders interlocks, and yet is fully protected at every point.



THE EDISON UNDERGROUND SYSTEM IN 1883

The Progress of Distribution

HAVING now traced to some extent the technical means by which current is at present sent out, it may prove interesting to look at the process of distribution from a geographical standpoint. This will be done in order to describe somewhat the development of the underground system, and to give some account of the varying demands made upon it today.

For convenience, in discussion of the subject, New York may be divided into four districts corresponding in general with what the company calls its operating districts. The first of these extends from the Battery to the region just north of Washington Square. The second district takes in all the city between Eighth Street and Fifty-ninth Street, while the third stretches northward to the Harlem River and the Bronx division, as the name suggests, supplies that borough. It should be borne in mind, however, that though these districts are said to begin and end at certain points, their feeders interlace forming a continuous underground mesh.

It seems to be the rule in New York that everything grows by stretching northward, and to this custom the electric lighting system is no exception. Thus, by starting with the southern part of the island, and working uptown, one is able to follow

the history of the Edison distributing process. The present first operating district includes, of course, the original square mile of territory which was supplied with current at the opening of the old Pearl Street station in September 1882. One of Edison's most far-reaching ideas, in planning for the incandescent illumination of New York City, was his scheme of a distribution system which should be located entirely underground, free from all atmospheric disturbances and from other interferences to which overhead wires might be subjected. Many had been the predictions that such an arrangement could not be made to work; that all the electricity would either escape into the earth, or that if enough were forced into conductors to overcome leakage, the conductors themselves would be destroyed.

Edison's ideas on this subject were most complete. He divided the city into sections of about a square mile, in each of which, he said, a central station should be located. From each station there should radiate many "feeders," as he called the conductors. Each feeder was to supply its own "junction-box," located at some street intersection, and no service connection was to be made to any feeder, but a series of mains was to extend throughout the district from which the services were to be taken. The mains of the several districts were to be tied together, and his conception was a continuous intermeshed network extending throughout the city, fed at various points by central stations. The success of the original First District system proved the feasibility of this plan.

In each of the aforementioned junction-boxes, there were two rings to which conductors in the feeders were connected by means of a copper tipped lead connection strip or "safety-catch." To the same rings, and by means of similar but lighter weight safety-catches, a number of so-called mains were connected. There was one main for each side of the street in all four directions and these were continuous to a similar, but somewhat smaller, junction-box located at the next street intersection. As every size of conductor was made up into standard lengths of about twenty feet, enclosed in an iron pipe, there was

FIFTH AVENUE, FROM TWENTY-FIRST STREET
Nueva York Ilustrada, 1886. A C Warren

a joint in front of every house; and it was, therefore, an easy matter to connect to the main a service to be carried into the premises of any would-be consumer. Throughout the system, resistance was placed to regulate any possible drop in voltage.

In general appearance this tubing, sometimes termed Kruesi tubing, from Mr John Kruesi under whose supervision it was made, was the same. In both feeders and mains the conductors were made of half round, drawn copper, which, after being served with rope wound in a long spiral over each of them, were placed with the flat sides toward each other and again served with rope to hold the two together. This couple was then inserted into a length of iron pipe, about six inches shorter than the conductors. An insulating compound was forced through the pipe, completely filling all the unoccupied space and serving further to insulate the conductors from each other as well as from the enclosing pipe. The ends of the pipe were then closed with wooden plugs and it, with the projecting conductor at each end, was ready to be laid into the ditch which had been prepared, there to be connected as one link in the continuous feeder or main.

The connection was made by almost rigid U-shaped joints which were slipped over the conductors, fastened in place by set-screws and soldered. These joints were protected by coupling-boxes which were clamped to the pipes and which were also filled with insulating compound, heated and poured in after the box was in place. Mains and services differed only in size. The feeders generally

carried two extra, separately insulated wires called pressure or galvanometer wires, the function of which was to enable the central station man to learn at will the pressure at the distant end of the feeder. This he did by connecting any selected wires to a detecting instrument such as a galvanometer, and he was thus enabled intelligently to use any regulating devices that were at his disposal.

During the laying out of the First District, in order to determine the sizes of conductors that should be used, a most elaborate survey was made of the territory. Every house was canvassed, every gas-jet counted, every horse-driven treadmill and every engine recorded. Large scale maps of each street were drawn to which the data collected were transferred so that the exact size of the conductor in each street could be reckoned with an accuracy so great as to be practically scientific. Probably the Gas Company reaped a golden harvest from the midnight gas that was burned while discussion went on as to whether the size of the main to be laid on a given street should be No 4 of 182,000 circular mils, or No 5 of 107,000 circular mils.

The same painstaking care was devoted to determining the proper size for each of the twenty feeders, and then further calculation was made as to what would be required in each feeder to make them all of nearly equal resistance, or, as they expressed it, to arrange them equipotentially. A scrutiny of data, in accordance with which conductors were manufactured and which may be found in the chapter on statistics, will show the factors which had to

be considered. The column headings are: number of feeder tube and copper; length of each feeder from catch-box to elbow in front of station curb; length of No 3 copper from elbow through cellar wall; equivalent length in main copper of feeder; length of No 2¾ copper from cellar to station mains; equivalent length in main copper of feeder; length of each feeder from elbow to station main; equivalent length of this part in main copper of respective feeder; length of each feeder from catch-box to station main; equivalent of each feeder from catch-box to station main; equivalent length in No 3 copper (circular mils 252,951); carrying capacity as compared with No 3 as unity; carrying capacity as compared with No 18 as unity.

One feature of the underground system, which later aroused a great deal of interest, was a small iron box set in the sidewalk, close to the curb line, and about twenty feet from the intersecting street. This was a one-conductor disconnection box, designed with the idea that should it be necessary to cut current off the entire main or any block front, as in case of an extensive fire, it would be possible to do so from this box, even though the regular junction-box were obstructed by fire-engines or rendered difficult of access by ice or snow. This device would, of course, effectively open the *metallic* circuit when the safety-catch on the single conductor in the box was removed; but it would not cut current off the line in case of a grounded system, where the ground happened on the conductor which was looped through the disconnection box. These boxes were

A SUBWAY SHAFT ON BROADWAY
Drawn by Vernon Howe Bailey

laid in the northerly part of the district after which the idea was abandoned and those already in place were disconnected. Three of them are still to be found where they were originally located; one on the east side of Cliff Street, twenty feet south of Beekman; one on the south side of Peck Slip, eighteen feet east of Water Street, and another on the west side of Water Street, twenty feet south of Peck Slip.

The safety-catches used at first were made of strips of sheet lead, through which holes were punched for a stud-bolt to fasten them in place to the rings in the junction-boxes. It was early seen that expansion and contraction of this soft metal would result in poor contact, and improvement was made by riveting and soldering the lead strips to copper tips which, it was expected, would remain firmly seated under the bolt-head. It was found, however, that the copper tips became corroded, and the next improvement was to have them plated with gold. This work was done at the very interesting shop of P A Normandeau at 50 Ann Street, one of the company's very first customers, and the use of the gold plated safety-catch was continued up to as late as 1888. The idea was excellent, but its value was rather lost when a husky jointer vigorously rubbed the tips with coarse sandpaper "to make a good bright connection."

A great deal of reliance seems to have been placed on the safety-catches and they were used, not only in customers' premises, but on all the mains and feeders in the junction-boxes, on the station ends of

the feeders, and even in dynamo circuits. The special function of the safety-catch was to open the circuit by fusing in case of trouble, and they were very closely calculated to "blow" if the load exceeded 100 per cent above their rated capacity. Lack of uniformity, however, in the mixture of which they were made (60 per cent lead, 40 per cent tin), coupled with occasional loose contacts, made them not over-dependable. Dr S S Wheeler, who succeeded Mr C S Bradley as electrician of the company, relates an instance in which the safety-catch, instead of protecting the system, caused a complete shut down. During a period of heavy load one or two defective catches melted, thus cutting off their respective feeders. This put extra load on the remaining feeders and a few more catches melted either in the station or in the junction-boxes, thus still further overloading the remaining catches. In a few minutes they also melted, one after the other, putting out all the lights in the district. It took perhaps three hours to replace blown fuses and restore lighting to normal conditions. Dr Wheeler says, "No one could have foreseen such an occurrence, but after several days' deliberation, the company concluded that it ought to give some apology to the public and make an example of some one. The apology was printed, and I was apparently selected as the example. I was discharged, to be immediately re-employed with Mr Edison's approval, and was sent to lay the wires in Fall River and Newburgh." This was one of the two breaks in Edison Service, the other being the Pearl Street fire in 1890.

This made a deep impression on all concerned and, although they were not prepared at that time to adopt the real safety-catch which is used at the present day—that is, a link made of copper only—they took extraordinary precautions to prevent a repetition of the trouble. In junction-boxes, safety-catches were frequently inspected and renewed, contacts thoroughly cleaned, and bolts firmly set up. In the station, a trough was built along the line of fuses on the feeder terminals. Every afternoon, at time of heavy load, lumps of cracked ice were fed into this trough and moved up against the lead catches to keep their temperature below the melting point.

As it was desirable to keep the insulation up to a high standard, a great deal of thought was given to the possibility of measuring the insulation while carrying current. This was done by means of a modification of the Wheatstone bridge invented by Mr C S Bradley, and in daily use up to the time of the fire, January 1 1890, when it was destroyed.

During 1889, Dr S S Wheeler, Professor F B Crocker, and Mr Gano S Dunn, experimented in the Thirty-ninth Street station, endeavoring to modify this invention of Mr Bradley's so as to make it applicable to measuring the insulation of live conductors in the three-wire system. They were not successful, however.

An apparatus was also used in the old station for locating grounds on the underground system. One part of the device consisted of a two-way switch, by means of which either conductor could be connected at will through an adjustable bank of lamps

THE CITY AND THREE OF ITS BRIDGES

Seen from Governor's Island during the Hudson-Fulton Celebration

and a quick-break push-switch to the ground. The other part included a galvanometer, a reversing switch, and several sets of adjustable resistances, all arranged to be connected at will to the pressure wires of any feeder. When the ground switch was closed, the galvanometer needle was deflected proportionately to the proximity of the ground to the feeder being tested.

This apparatus was in regular use. Every evening a test was made of all the pressure wires and, guided by the galvanometer deflection, the night gang opened junction-boxes and tested the mains until the defective main was located in the section indicated. Digging on the line then followed until the fault was found.

The station was also equipped with a ground indicator, consisting of two lamps connected in series across the two conductors, with a wire leading to ground from the center of the connection. Under normal conditions each lamp showed a half light; but with a dead ground on the conductor, one lamp was dark and the other showed full candle-power. In the early years of the station's operation these lamps varied frequently with the shifting of the ground from one pole to the other, but in later years the negative pole became pretty solidly grounded so that the positive lamp remained at full candle-power all the time.

A diagram of the apparatus for locating grounds will be found in the chapter on statistics.

When the station was started there was no amperemeter equipment on either dynamos or feeders.

Shortly afterward, however, a meter was devised of the familiar coil type, the scale being graduated into divisions which indicated lamps. The graduation into amperes was not adopted until late in 1886. These meters were connected in series with each dynamo circuit, but probably the need for economy prevented their installation on feeders. A very crude device was made for use on the latter, consisting of a rough block of wood carrying a common sewing-needle suspended between two brass screw points and free to swing. This block was sprung over one of the conductors of each feeder and the magnetic field created by the passage of the current over the conductor caused the needle to be deflected outward. A cardboard scale, crudely graduated, gave an approximate idea of the number of lamps being carried by a particular feeder.

Before leaving the history of the First District underground system, it is worth while to mention that in 1890 the work of laying three-wire conductors in this region was begun. That year 8.95 miles of three-wire feeders, together with 13.29 miles of three-wire mains were put down. At the same time, a little over two miles of the old two-wire conductors were removed. This process was continued at such a rate that in 1897 only 0.17 mile of main of the original two-wire system remained.

Today the first operating district of The New York Edison Company has seven distributing points. Of these, the Bowling Green station is the most southerly. It, together with the Water Street station, supplies the great financial region of the city

as well as docks, shipping interests and wholesale coffee and tea houses.

By an odd coincidence, the Gold Street substation supplies the jewelry district. It also sends out power to "newspaper row," to "the swamp," famous for its dealings in leather, and lights St Paul's Church. Old Trinity, by-the-bye, gets its current from Bowling Green. Duane Street also has newspapers for its patrons, besides the City Hall, the new Municipal Building, and the wholesale dry-goods district to the west.

The Vandam Street station is located near old Greenwich village. Here residences are giving way to warehouses, factories and loft buildings, which require power as well as light. Factories also patronize the Crosby Street station which serves offices along Broadway and shops in Chinatown, besides lighting the Bowery. From the Clinton Street station, power goes out to numberless small factories and stores in the East Side, while its current also lights the Williamsburg Bridge.

The second operating district began its work with the opening of the Thirty-ninth Street plant in November 1888. From the first, it was laid out with the three-wire system. In 1893, the district extended from Eighth Street to Fifty-ninth Street —as far north as the company had any business, with the exception of Fifth Avenue where lighting reached to Seventy-ninth Street. At this time, current was generated at the Twenty-sixth Street, the West Thirty-ninth Street and the Fifty-third Street stations. On Sundays and during the night

THE BOWERY
Drawn by Joseph Pennell

the company shut down all but Twenty-sixth Street and carried the entire load from there, feeding to West Thirty-ninth Street on a tie-feeder, making the same connection with Fifty-third Street, and connecting one feeder to the Fifth Avenue lighting. These feeders carried, at times, as much as 700 or 800 amperes, in those days a heavy load. This method was continued for one or two years, after which each station had to work twenty-four hours a day.

Next, a steam plant was started at Twelfth Street between Third and Fourth Avenues and later a temporary annex was erected at Seventy-second Street and Fifth Avenue, where a motor-generator set obtained high-tension current from the Manhattan Company at Eightieth Street. This was run until the Eighty-third Street rotary station was built in the fall of 1898. The load in the district in the autumn of 1893 was about 30,000 amperes. In 1911, it had a maximum load of 465,900 amperes.

The second district, with its ten substations, now serves that portion of Manhattan Island between Eighth Street and Fifty-ninth Street, east and west to the rivers and, although it is not as large as the two other districts combined, it has carried fully 50 per cent of the total maximum load of the three districts for the past few years. It supplies current to almost every variety of service. Prominent among these are the department stores, the theatres and especially the Great White Way, with its myriads of scintillating lights and signs, from the single lamp type to the largest and most famous sign in the

world, the Roman Chariot Race, at Thirty-eighth Street and Broadway. Throughout the district in the vicinity of Fifth Avenue and Broadway the heaviest demand is located, and near these thoroughfares are the larger substations.

The most southerly station is the one at 30–32 Horatio Street, first started in 1900. It is equipped with three 500 and two 1000 kilowatt rotaries, 2150 kilowatt synchronous motor-generator sets, and two batteries. Here, also, are the offices of the company's battery department. Horatio Street station serves a varied class of business. On the west, it takes care of the shipping and wholesale work of the river front and on its east, it feeds into the southern end of the department store region.

Next comes the substation at 115 East Twelfth Street, which was started as a direct-current steam plant in 1895, though it soon outgrew this stage and now all vestiges of its former purpose have been removed. It has one 500, eight 1000 and one 2000 kilowatt rotaries and two batteries. This day station supplies a large manufacturing neighborhood including the dry-docks on the East River, and workshops and small stores of the East Side; while Fourteenth Street, with its theatres and cafés, together with the department stores on the north and west, gives this station a "two peak load."

The West Sixteenth Street station was started in 1907 and now has three 2000 and three 2500 kilowatt rotaries, some of the vertical type. Although built recently, its output is second largest in the district, this being due to its position in the department store

center and also to the northward movement of factories and loft buildings.

The Twenty-sixth Street station, which takes in the building at 45–51 West Twenty-sixth Street, and through to 44–46 West Twenty-seventh Street, was, in 1888, the second steam station in the second district; but now the keystone of the main arch is all that remains of the original plant. Last winter it had the largest output of any substation of the company. It is equipped with five 1000, three 2000 kilowatt rotaries of the horizontal type, three 2500 kilowatt rotaries of the vertical type, and three batteries. The side streets near the station constitute New York's fur market, while tall loft buildings are rapidly developing for manufacturing purposes in this vicinity and on Fourth Avenue. With the department stores on Sixth Avenue and the offices of Broadway and Fifth Avenue, this station has a heavy day load.

The substation at 452 West Twenty-seventh Street was started in 1903, and has three 1000 kilowatt rotaries and one battery, taking care of the large terminal warehouses and wholesale supply houses around Eleventh Avenue and the Hudson River.

Situated three stories underground, the station in the Gimbel Building, with its five 1000 kilowatt rotaries, is perhaps unique. It was started in the fall of 1910, only a short time before this monster shop opened, and it not only supplies current to near-by department stores, but also feeds into the Twenty-sixth Street station's territory on the south and in the direction of Thirty-ninth Street on the

FOURTH AVENUE AND TWENTY-THIRD STREET
Nueva York Ilustrada, 1886

north. Its compactness has brought forth much favorable comment and has been a strong factor in support of central station service for large establishments.

The 151 East Thirty-ninth Street station, built in 1906, has four 2000 kilowatt rotaries and two batteries. Although the service it renders is generally to smaller customers, with the exception of the New Grand Central Palace, Sherry's, Delmonico's and a few others, it has shown a great increase in output during the past year.

The theatrical district of New York centers around the station at 117–119 West Thirty-ninth Street. Built in 1888 as a steam plant, it is now equipped with two 500 and seven 1000 kilowatt rotaries and two batteries, and at night is considered one of the most important substations on account of the great number of theatres it supplies. Here, the deputy assistant superintendents may be found on duty from 4 P.M. to 8 A.M., and this is also the home

of the emergency department of the company, with its telephone switchboard that answers emergency calls. Here also are the second district store-room and headquarters for the meter test and arc departments.

Next in order is the 314 West Forty-first Street station, started in 1910, with one 500 kilowatt induction motor-generator set, two 2500 kilowatt rotaries and one battery. This helps West Thirty-ninth Street by taking care of part of the theatre load, and also supplies current to the rapidly increasing group of factories around Eleventh Avenue.

The station at 120–122 West Fifty-third Street was the most northerly steam plant built by the company for direct-current supply and was started on New Year's Day, 1893. Here the first storage battery used in three-wire central station work in the United States was installed. This battery was imported from England and had a very small output. But at that time this station served a wide territory and fluctuations were greater then than they are now, so that this comparatively small battery aided the regulation to a marked extent. It was through this substation that the illumination of St Patrick's Cathedral was carried out in 1912 with such success. This station has an installation of six 1000 and one 2000 kilowatt rotaries and one battery. With more of a residential service than any other in the district, it constitutes a night load center.

A comparison of the first English type battery at the Fifty-third Street station, with recent large installations whose outputs are from 15,000 to 25,000

amperes each at the one hour rate, shows clearly the strides which the storage battery has taken. This has been made necessary in order to keep abreast of other developments and to insure continuity of service.

The second district, as a whole, with its day load at its southern end and its night load toward the north, may be considered a good long load, rather than a peak load district.

The third district developed in the beginning as part of the second, the first plant established within its territory being the station temporarily equipped at Seventy-second Street and Fifth Avenue in 1896. Here, the company first converted high-tension current into low-tension for distribution, and as a result a permanent converting station was erected before long at Eighty-third Street, current for it being drawn from the Manhattan Company's plant at Eightieth Street. The next station to be opened was that at One Hundred and Twenty-first Street. This was in 1899, and it was followed by one at One Hundred and Twenty-third Street during the same year, and by the Eighty-fourth Street station early in 1900.

At this time, the territory was first organized as a separate district and other stations sprang up rapidly. One Hundred and Seventh Street was opened in November 1904; the Sixtieth Street building began its career two years later; and the Sixty-fourth Street started in October 1907.

The maximum load for the district in 1900 was about 2000 kilowatts, while 1911's maximum was 28,000 kilowatts, and this year's promises to reach

THE SOLDIERS' AND SAILORS' MONUMENT

On a rainy night during the Hudson-Fulton Celebration

about 31,000 kilowatts. Current in this district is supplied principally to residences and retail stores, there being little manufacturing.

Edison Service entered the Bronx in 1899. During that year there were approximately twenty-five miles of streets on which there were electric light lines, while at present 225 miles of street are so covered. On these lines in 1899, about 100 transformers had been connected, having a combined capacity of 700 kilowatts, or sufficient to light only 14,000 sixteen candle-power lamps; while at the present time there are 1289 transformers with a combined capacity of 17,088 kilowatts, or sufficient to light 341,760 sixteen candle-power lamps. Twelve years ago there were 800 arc lamps in use for street lighting in the Bronx, while at present there are 1867 arc lamps and 1144 incandescent, a total of 3011 lamps for this purpose.

During the year 1899, there were distributed from the station at Rider Avenue and One Hundred and Fortieth Street 2,000,000 kilowatt hours of electricity. This is current sufficient to keep 4566 sixteen candle-power lamps burning twenty-four hours a day for one year. In 1911, 27,114,000 kilowatt hours were distributed from the Bronx stations, or enough to supply 64,187 sixteen candle-power lamps twenty-four hours a day for a year. The maximum amount taken at any one time in 1899 was 1100 kilo-volt-amperes. If this had all been used to light sixteen candle-power lamps, it would have fed 22,000 of them. In 1911 the maximum amount taken was 13,000 kilo-volt-amperes, or enough to sustain 260,-000 sixteen candle-power lamps.

Briefly stated, there are in the Bronx district at present nine times as many miles of streets supplied with electric lines as there were twelve years ago; thirteen and five tenths times as much electricity delivered from these lines annually; twelve and nine tenths times as many transformers in use with twenty-four and four tenths times the total capacity; while twelve times as much electricity is taken on any one occasion.

Before leaving the subject of distribution, it should be stated that in 1901, owing to the spread of high-tension transmission, an electrical engineering department was formed to supervise the distributing system. Under the jurisdiction of this department come the design and operation of high-tension switchboards and apparatus both in stations and substations, and also of all relays and protective devices. The planning and laying out of the distribution network, including low-tension and high-tension feeders, is part of its work as well.

Some years ago most high-tension switches in the substations were of the expulsion type, and the disconnected switches were of the copper blade exposed style; but at that time the standard of construction began to change, oil switches of the automatic and non-automatic type, enclosed variety, being substituted. Another duty of this department was the development of speed limit devices for rotary converters, and the arrangement, in inverse time limit, of relays for high-tension circuits which were first installed in Waterside No 1. These were probably the first of their kind in this country.

COURT OF HONOR—THE HUDSON-FULTON CELEBRATION

Designed by Mr C F Lamb

Marketing Light, Heat and Power

DURING the first decade of the Edison system's existence in New York, its efforts were put forth in meeting engineering problems. Feeders and mains had to be laid; plants had to be built; and each undertaking brought up new problems to be solved by the perfecting of equipment and methods. In those days, the question was never how to induce more people to use electricity, but rather how to produce enough current to answer the most pressing demands for it.

Toward the end of the year 1892, however, a generating unit, gigantic for that time, was installed in the Duane–Pearl Street building. It could develop 2500 horse-power, and its capacity was twice as great as that of the entire old Pearl Street station, while it occupied only one tenth the floor space. Plans called for ten such units to be set up in the operating room at Duane Street, and at last the company's officials saw that they would be able to manufacture more electrical energy than was actually being called for.

It was at about this time, then, that the company began to interest itself vitally in the problem of business-getting. Records of that period show an immediate and rapid rise in the number of customers and in the size of their installations. For, while in 1890 there were only 1698 consumers with a total

Marketing Light, Heat and Power

DURING the first decade of the Edison system's existence in New York, its efforts were put forth in meeting engineering problems. 'eeders and mains had to be laid; plants had to be uilt; and each undertaking brought up new prob- ems to be solved by the perfecting of equipment and ethods. In those days, the question was never how induce more people to use electricity, but rather ow to produce enough current to answer the most ressing demands for it.

Toward the end of the year 1892, however, a gen- rating unit, gigantic for that time, was installed in e Duane–Pearl Street building. It could develop 500 horse-power, and its capacity was twice as great s th of the entire old Pearl Street station, while it only one tenth the floor space. Plans called h units to be set up in the operating room Street, and at last the company's officials they e able to manufacture more al ene as actually being called for. as at me, then, that the company to i vitally in the problem of rds of that period show an rise in the number of custom- their installations. For, while aly 1698 consumers with a total

of 64,174 lamps on a sixteen candle-power basis, they had grown by the end of 1893 to 5154 customers, who used the equivalent of 192,691 sixteen candle-power lights. During the same time the aggregate horse-power in motors had increased from 697 horse-power to 5529. In this same year, 1893, the contract and inspection department was established, the company having given up its wiring business in favor of outside firms. This made it possible to rearrange and concentrate, bringing into one department those branches of the organization which dealt directly with the public. Since 1892 the company's business has advanced from a total of about 196,932 fifty-watt equivalents to one of 10,705,000.

Today the marketing of light, heat and power—which means, of course, the getting of new customers and the keeping of old ones—may be said to have five phases. These are: meeting the customers; furnishing them with expert information as to their installations; making known the advantages of the central station system through advertising, direct as well as indirect; training intelligent and courteous salesmen; and recording the company's affairs by means of clear, comprehensive accounts and statistics. The part played by each of these divisions in the growth of Edison Service is the next thing to be considered.

First in importance, probably, come direct dealings with customers themselves. For this purpose, district offices have been opened in various parts of the city. They are intended primarily for the

greater convenience of patrons and prospective patrons. For instance, it would be most annoying for a man living in Harlem to journey to Duane Street to pay his lighting bill, or report any difficulty in the use of lamps or machinery. Again, a retail merchant in Rivington Street, who might think of installing electricity in his shop, would be far more likely to carry out his intention if he could make all inquiries and even sign a contract at a sort of commercial substation in his own neighborhood.

Accordingly, the company maintains branches at 424 Broadway; Delancey Street; Forty-second Street with a Third Avenue annex; in Harlem; and in the Bronx. So diverse are the interests in these different sections that each office would almost seem to answer the needs of a separate city; for 424 Broadway has as its patrons many great financial, commercial and wholesale organizations, while Delancey Street, on the other hand, serves owners of small factories and shops in the East Side. Forty-second Street, with its annex, numbers among its customers theatrical firms whose names are blazoned on bill-boards all over the country, department stores equally noted, advertisers who have come to fame and fortune through their electric signs, as well as fashionable folk whose homes form part of the stock-in-trade of sightseeing automobiles. Farther uptown there is more and more residential patronage, to which the Harlem and Bronx offices bend their attention.

It is the work of employees in these offices to acquaint themselves with the character of demands

for light, heat or power in their particular districts. Thus, contracts which have no unusual features are carried out directly in the district offices, which serve, besides, as disseminators of information with regard to central station current. By a careful sub-

MR EDISON EXAMINING A NEW ELECTRICAL PROTECTING DEVICE

division of duties—about which more will be said later—The New York Edison Company makes it practicable to treat every customer with equal consideration. It is its desire to give courteous attention to each consumer, whether he has two incandescent

bulbs over a fruit-stand or a large equipment of current-driven machinery.

In addition, each office is used as a show-room where all kinds of electric fixtures and instruments are exhibited, for the central station is under obligation to keep the public informed as to all progress in applying current to business or daily living.

Now The New York Edison Company deals only in electric energy, and the wares shown in its offices are sold without commission or profit of any sort, the ultimate and only gain for the company being the increased consumption of current brought about. Moreover, rival makes of implements are exhibited without discrimination.

This leads directly to a second branch of the marketing process; that is, the providing of expert advice on electrical matters to all consumers of current. Such advice, however, is not given by the district offices, but by a series of bureaus organized to co-operate with them. The day has long since passed when any one man could know everything about electricity supply, and it has become necessary to have specialists in different forms of the industry, whose knowledge is placed at the disposal of any district office, and so of any inquirer.

Thus, if the owner of a building wishes to learn what lighting arrangements will best answer the business needs of his tenants, he is referred to the bureau of illuminating engineering. Plans, with estimates of probable cost, will be made out for his inspection without in any way binding him to accept them. Again, a factory proprietor, in doubt as to

FIFTH AVENUE AT NIGHT
Drawn by Vernon Howe Bailey

how many electrically driven machines would best suit his purpose, may consult the power bureau; or a housekeeper may have the advice of specialists in heating and cooking utensils. In every case, it is the company's policy to recommend what will give most thorough and lasting satisfaction to the future customer, for only in this way can a whole-hearted convert to central station service be gained.

It is right to make here more than a casual allusion to the growth of the heating load, since this is one of the newer developments of current supply, and since much is expected of it in the future. Until 1907, comparatively few electric heating or cooking appliances were used even in homes, and practically none in factories. That year, however, manufacturers of these devices improved their output to a marked degree, so that in 1908 the heating bureau employed several demonstrators and set about creating a demand for these implements. Since then there has been a steady rise in installations. In 1911 about 10,000 manufacturers in New York City were using heating appliances and 22,450 pieces had been placed during the year. In 1912 that amount was doubled.

The equipping of large public buildings like the Metropolitan Opera House or the Hippodrome so as to preclude any interruption in lighting is an important undertaking. It is not only necessary for business reasons that such service should be dependable to the last degree, but it is also imperative for the safety of the thousands of people who form the audience, since a panic would be easily started by

sudden darkness or some other slight mischance. The planning of convenient, complete and reliable systems for such uses is the work of the service engineering bureau.

Experience has proved that men accustomed to think usually of large installations are not equally successful when they turn their attention to small ones, and the reverse is also true. For this reason, separate wholesale and retail bureaus have been formed, so that a customer's needs, whether great or small, receive proper attention; while the commercial engineering bureau exists in order that no technical question submitted to the company may go unanswered.

The New York Edison Company years ago encouraged electric signs, seeing their unique advertising possibilities. Today, contracts for many of the glowing bill-boards which line Broadway are made through the bureau of signs. Within its jurisdiction also comes the supplying of both signs and tungsten lamps on the instalment plan.

In the isolated plant bureau are experts who stand ready to lay before the unconvinced, proof of the greater safety and economy of central station supply. Workers in this branch of the company must possess knowledge not required in its other divisions. They must understand the questions of coal supply and steam manufacture. Above all, they must be familiar with real estate values in this city, for this is often a prime factor in leading a manufacturer or merchant to give up his private plant. The automobile bureau, in turn, is able to go deeply into the fitness

LOOKING DOWN BROADWAY TOWARDS THE TIMES TOWER

of electric trucks or delivery wagons for varying uses, advocating current-driven vehicles as the cars of the future for city needs.

The bureau of special service looks into any complaints from patrons. Shakespeare to the contrary notwithstanding, there is a great deal in a name, and it is deemed more tactful to indicate by the title that this bureau exists for careful adjustment of difficulties, rather than for filing grievances.

A somewhat similar office with regard to bills is filled by the lighting inspection bureau. It has been discovered that the very qualities which make a good sales-agent, impair his value for dealing with complaints. He is generally not a technical man and he does not know from actual, personal experience that the electric meter is one of the most reliable mechanical devices ever invented. Consequently, when a customer declares that his meter is inaccurate, the agent is inclined to sympathize with the complainant even before the trouble has been investigated. For these reasons, the company has arranged a bureau of men especially trained on the subject of meters. They know that a meter almost never lies and that there may be other causes for the apparent discrepancy. At the same time, it is the unvarying practice of the company never to conceal a mistake. If one is discovered, it is admitted and rectified, for the public should know the truth about meters to the end that confidence may be established.

Advertising is a far-reaching factor in any business. In the electric lighting industry, every incan-

descent bulb is a subtle reminder of the cleanliness and convenience of this illuminant. Every home made more comfortable by current-fed appliances is an object lesson to the nonconsumer. Every satisfied patron becomes an advocate. A good many years ago the makers of some patented article coined the phrase, "We are advertised by our loving friends." All that was very true, but it was also noticeable that this firm purchased space in newspapers and street cars so as to keep its slogan well within range of the public eye.

The New York Edison Company's advertising—in charge of a bureau—was carefully planned, typographically and esthetically, long before many advertisers had learned the advantage of good taste and discretion in this direction. In 1905 the phrase "At your service" was adopted in the company's advertisements, being a most succinct and happy statement of the fact that a public utility organization is truly the community's servant. Today The New York Edison Company's is probably the most extensively copied corporation advertising in the world, and is constantly mentioned in journals concerned with this branch of printing and publishing.

Forwarding the interests of the central station in a more personal way is the work of the follow-up bureau. As a rule, large firms spend much thought and money on out-and-out advertising, but they often fail to drive this home by secondary methods. In the follow-up bureau every effort is made to interest people who may in time become consumers. A million and a half communications go through

ANOTHER VIEW OF MR EDISON EXAMINING THE NEW PROTECTIVE DEVICES AT THE OFFICES OF THE NEW YORK EDISON COMPANY

this division in a year, materially helping the company to keep in touch with possible customers.

The editorial bureau exists for its indirect advertising value. Besides issuing *The Edison Weekly* —which, being intended solely for the company's employees, will be described in that connection—it publishes *The Edison Monthly,* a magazine with a circulation of 25,000. This periodical recounts interesting applications of electricity in every walk of life, devoting especial attention to Edison Service in New York City. The policy followed is to make the magazine readable, attractive, and of value for the news it contains.

Mention of the *Edison Monthly* leads one naturally to the photographic bureau, for many illustrations in the magazine are its work. This bureau has made a specialty of night photographs of New York City, which have been widely copied on account of their picturesqueness.

Having provided for attention to customers, and for advertising which will gain new adherents, the next step in the business of selling current is to train salesmen. This is the purpose of the educational bureau's commercial school. A detailed account of its courses will be found in the chapter devoted to the Edison employees. Here it is only necessary to state that this is a school of salesmanship planned to give employees an understanding of the commodity which they sell, and a knowledge of the most courteous and effective ways of approaching possible customers. A graduate of these courses possesses, besides his diploma, a belief in central station service. He knows that he is urging the use of something worth buying. But beyond all this, the school teaches men to be men, and a graduate to whom one of its "A" certificates is awarded has had instruction as valuable as that afforded by many college courses.

This subdivision of the marketing process would be incompletely mapped out if no means were at hand for recording scientifically all information as to the company's affairs. This, then, is the province of the statistical bureau and of the accounting department.

By the former, detailed charts are kept showing the growth of various branches of current supply;

FIREWORKS AT THE OPENING OF THE HUDSON-FULTON CELEBRATION

A most effective night view from Shadyside, New Jersey

as, for example, increase in the incandescent lighting load, the power load or the heating load; and these records—minute and complete—are arranged particularly to elucidate problems arising in marketing. Thus it is possible to trace effort expended and result obtained, from week to week or year to year.

The accounting department is the outgrowth of a clerical force of two, which, in 1882, recorded customers, collections and disbursements; did all the general bookkeeping of the company; and attended to meter work. Today these tasks are divided among the "accounts receivable" bureau, the "collection," the "payroll and timekeeping" and the "accounts payable" bureau, the treasury department and the general accountant.

The original two men have been succeeded by a force of 473, consisting of 76 meter indexers, 77 bookkeepers, 33 bill clerks, 51 general and statistical clerks, 45 employees of the collection office, 60 collectors, 20 employees of the accounts payable bureau, 2 general accountants, 30 members of the payroll office, 35 timekeepers, 7 paymasters and 30 people in the cashier's department.

Among the books and papers of the accounting department, many interesting facts as to the company's history may be gleaned. In 1882, it may be noted, current cost customers about twenty-two cents per kilowatt hour, while at present the average rate is about six cents. In addition to this saving in the unit cost of current to the consumer, great improvement has been made in the efficiency of incandescent

lamps. From a consumption of four watts per candle in 1882, this has fallen to one and one quarter watts in 1912. This means that a person using four sixteen candle-power lamps, three hours a day for one month in 1882, would have paid $5.67; but today an equivalent amount of illumination, calculated at the maximum price of ten cents per kilowatt, would cost seventy-two cents.

At the beginning of 1883 the company employed the Edison chemical meter for measuring current. This required many operations in delivering and collecting plates, weighing with fine scales the outgoing and incoming plates, and translating the difference into lamp hours. The entire process was tedious as well as involved, and had a decided disadvantage. No possibility existed by which the customer could ascertain the extent of his use of current, determination being absolutely in the hands of the company. It should be recorded, however, to the credit of the managers of the company in early days, that bill questions were no more frequent proportionately then than now; although today, besides modern metering, the consumer has the added protection of the Public Service Commission.

Accounting methods have been influenced by time and growth of business. Two absolutely new factors have been introduced into office operation: the presence of women employees, and the adoption of mechanical aids. These latter include typewriters, calculating machines, duplicating processes and stamping and mailing devices. Both the human and the mechanical innovations made their appearance

THE LIGHTS OF BROADWAY
Drawn by Vernon Howe Bailey

at about the same time. All mechanical devices used by the company are electrically operated, thereby greatly increasing their productiveness and ease of operation. Reviewing the thirty years, probably the most significant advance in accounting work has been in the direction of scientific cost keeping and analysis, and of statistical work generally. Recognition of the characteristics of maximum demand costs and running costs, and the part which the diversity factor plays in the economics of business, have all followed as the result of improvements made in cost accounting and in statistical methods. Much more is demanded of the accounting department of today than thirty years ago. Now it records the activities of the entire organization, and from its books one can obtain an adequate notion of work in every branch.

Thus two modern tendencies, one toward specialization, the other toward more thorough record keeping, have entered into the marketing question and have changed it from a primitive bargaining contest to a study in psychology.

Street Lighting

IT was not until 1889 that an arc lamp was perfected for connection to the direct-current multiple service. Prior to this, there were many companies in New York City which had in service series arc lamps supplied from arc generators. These were the only available units of high intensity, and the companies were organized chiefly for supplying arc service, their circuits including lamps for commercial purposes as well as for street lighting, the major portion of their business. There was but little demand for motor service, and this in very small units. Commercial lamps were charged for on a flat rate with varying schedules, which included lighting from dusk to eleven o'clock, from dusk to twelve, and from dusk until one o'clock, as well as for all night. The circuits were controlled from the station, such lamps as burned less than all night being put out by a patrolman who visited each installation.

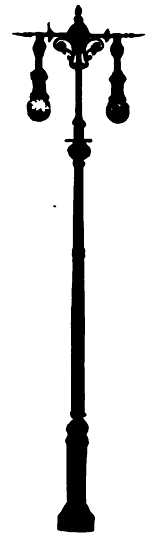
About this time the "Ward" type of multiple two-in-series arc lamp passed out of the development stage and was made part of the equipment furnished by this company. These lamps were adjusted so that the cur-

rent consumption was eight amperes per pair, with an arc potential of from 45 to 50 volts, and were connected in pairs across the 120-volt mains through a German-silver steadying resistance. The control of the lamps by the customer, the use of them on a meter basis as compared with series arc service, together with their design, presented so many desirable features that a total of 110 lamps was installed during the year of their adoption. This type was simple in construction, easily maintained and was not superseded by any other form until the advent of the enclosed long-burning style, a fact that speaks well for its operation and equally well for its maintenance. Further improvement in operation resulted in increasing the life of the lamp from six hours to ten hours, and later, in the use of high-grade imported Nurenberg carbons, which steadied the light and overcame the hissing that accompanied the earlier type of carbon. By 1896 the installation of these lamps reached a total of nearly 4000, when the enclosed long-burning lamps commenced to replace them.

The extension of the multiple two-in-series type of arc lamp to street lighting commenced in 1892, when Fifth Avenue from Washington Square to Fifty-ninth Street was illuminated by posts each supporting a twin fixture with two lamps. This arrangement, designed by the

Illuminating Company, was manufactured for the Edison system by Mr S Bergmann for the Columbian Anniversary Celebration. Appreciation of what was at that time a radical departure from established practice, was shown by the Commissioner of Public Works, General C T Collis. He made a visit of inspection abroad, and

on his return he reported: "No street lighting in Paris or London excels the Edison lamps for beauty and illumination." In these particular lamps, effort was made to increase the life of the carbons by additional length between lamp centers, and by a globe which, set tightly into a metal casing, protected the arc from drafts. Besides, a specially high grade of imported carbon was used. By exercising the greatest ingenuity and watchfulness the arc lamp department of



those days maintained the lamps so that they would burn through the longest winter night. The lamp's design and the construction of casings were such, however, that often in winter every man in sight and able to handle a gasolene blow torch had to be drafted to thaw ice off holders, and so make it possible to trim the lamps for the night's use.

Notwithstanding the fact that they were innovations, the early multiple arc lamps of this company showed themselves at once to be superior for street

illumination to long established series arc lighting systems. The installation of lamps on Fifth Avenue in 1892 was the foundation of the present arc lamp equipment in New York streets. In 1896, this service was extended to include Madison Avenue from Twenty-third to Seventy-ninth Streets and several side streets near Central Park.

The development of the long-burning enclosed arc lamp was completed in 1896, and it found immediate popularity. This will be appreciated, for the life per trim of a single pair of carbons was increased from eight to ten hours in the old style open arc, to approximately one hundred hours in the new type. In addition to the impetus that naturally resulted from this increased life, the new lamp gained because of individual control of each single unit.

The extension of enclosed arc lamps for street lighting as well as to the customers of this company was very rapid after 1896 and in 1898 reached a total of 7000 lamps. Ten years later this total had been increased to 46,000 lamps for both classes of service. The years between 1898 and 1904 formed a transition period in the arc lamp service, owing to the fact that various arc lamp systems were maintained, being those of the several companies which later became parts of The

New York Edison Company. Among the lamps used at that time were series open arcs of the Brush, Thomson-Houston, Schuyler and Excelsior types; alternating-current multiple lamps of a 35-volt type operating from "economy coils"; enclosed lamps of both the alternating-current series and multiple type; and direct-current multiple enclosed arc lamps. In 1904, the change from various systems of supply was completed and since then multiple enclosed arc lamps alone have been installed for both municipal and commercial lighting on Manhattan Island.

The growth of high intensity arc lighting has been slow compared with that of incandescent lamps, but it has been steady and constant. Following its customary policy of investigation and of testing new apparatus, this company installed, early in the development stage, Blondell and Bremer types of flaming arc lamps in the large squares of the city. The company also coöperated with municipal authorities in investigating the merits of flaming arc lamps for armories and public buildings, trial installations of several years having decided for a general introduction. As a result, several armories have already been equipped with the higher efficiency lamps, while others soon will be. Investigations have also been extended to arc lighting units designed espe-

THE BISHOP'S CROOK

cially for street lighting, such tests including both metallic flame arc lamps and long-life flaming carbon lamps.

Street fixtures for municipal lighting were early made the subject of careful consideration by those determining the policy of the company. In contradistinction to former practice, Edison lamps were installed from the beginning on ornamental iron posts superior to any then used in this country. This custom has been followed ever since, and today standard equipments in New York City are of high artistic excellence. The report of the Edison Electric Illuminating Company for 1897 said: "Development of enclosed arc lamps has made possible a similar remarkable development in low-tension street lighting. After a careful collection of views and plans of arc lamp posts used in various cities here and abroad, the engineering department designed a new form of post for city lighting, of artistic pattern. This has met with general approval. This post bears on its base the arms of the city and the seal of the Edison Company, and is surmounted by a graceful curve in place of the awkward yard arm."

The design of the posts has always taken into consideration electrical features necessary to the lighting unit employed, and those now available are suited to the varying conditions found in a large city. Different styles are used for wide, tree-lined thoroughfares; for large squares or the middle of roadways; and for residential as well as congested districts. Many features require careful consideration, and

have been made possible only by full size models prepared in advance from plans of the engineering department. Harmonious ornamentation suited to the lamp structure is thus worked out, as accompanying illustrations show. Decorative street fixtures also include those used for parks and parkways, and within the last three years a total of over 2000 tungsten lamps have been added to the municipal lighting.

Since electric automobiles have been available for the work of the arc lamp department, every advantage has been taken of their possibilities. Heavy castings, steel tubes, and various parts that go to make up the city street lighting equipment are installed most economically and safely by labor-saving appliances. Full use is made of the electric winches connected with truck batteries, and the drilling of holes is performed by electric power drills furnished with current from the same source. The latest design of specially constructed tower for trimming and emergency repairs at night, is mounted on one of the company's high speed, 1000-pound wagons. The tower weighs 300 pounds and has a working platform which can be adjusted above the roadway twelve to twenty feet.

The foregoing allusion to the company's electric automobiles describes only a few of the many uses to which they are put. In all, 104 current-driven vehicles are used by the Edison system. Of these, twenty-five are for passengers and thirty are delivery wagons for incandescent lamps. Then there are twenty-three 2000-pound wagons for delivering sup-

TRIMMING A LAMP

plies to work in progress, six 3000-pound wagons for taking meters to similar destinations and one 4000-pound wagon to carry wiring materials for the same purpose. One 3½-ton truck and five 5-ton trucks pull cables through conduits, while one truck of the last mentioned size is assigned to general orders and

ERECTING A LAMP POST

freight work. For these last duties, there are also one 3-ton truck, one 4000-pound wagon and one 700-pound wagon. The arc lamp post service has one

$2\frac{1}{2}$-ton, and one 3-ton truck. In addition there are six superintendent's wagons and one 700-pound wagon for inspection work.

A MAST ARM POST

Concerning Meters and Testing

THE first bill for current presented by the Edison Electric Illuminating Company, was dated January 17 1883, and made out to the Ansonia Brass & Copper Company at 15–17 Cliff Street. It was for $50.40 and had been determined by means of the Edison chemical meter. Thus, from the beginning, the New York Edison system set itself to sell current by meter rather than by contract.

It may be interesting briefly to summarize the routine that had to be followed in those early years to render a bill for current. The initial operation was to prepare the zinc plates by cleaning them in acid and carefully amalgamating them with mercury to obtain a chemically clean surface. After drying, they were buffed to remove the loose particles of mercury and weighed by delicate balances. Coupled with insulating buttons, they were set in bottles and carried out to be installed in the meters. The bottles were brought in and out of the department at least every month, while the very first meters provided for a quarterly as well as a monthly bottle for checking purposes.

During 1893–1894 consideration was first given the mechanical meter. The disadvantages of the chemical meter—with the entailed labor of weigh-

ing 20,000 plates per month for every 5000 customers and the subsequent handling in customers' premises—pointed to the necessity for a different type of meter. Various styles of English as well as of American make were tested, but none of these compared favorably for general accuracy with the chemical type.

In 1896 the Thomson meter had, in the opinion of the company, passed out of the developmental stage and some of them were installed on the system, although the greater proportion of the 8532 meters on customers' premises were still chemical. During 1897, 6744 mechanical meters were placed in service.

The history of the electric meter in The New York Edison Company is, briefly, as follows:

1880 First electrolytic meter made at Menlo Park.
1882 First chemical meter for commercial service installed on mains of old Pearl Street station.
1883 First bill rendered from electric meter in New York City.
1883 to 1896 Increase in chemical meters to 8500.
1893 First investigation of Thomson mechanical motor meter.
1896 Initial installation of twenty-five mechanical meters in series with chemical meters for comparative service.
1902 First investigation of new design of mechanical meter known as "Type C."
1912 159,000 meters in service.

The installation of improved designs in meters and the retirement year by year of thousands which have been superseded, have kept the company's meter service in the forefront of the growth of electrical industry. In recent years, the Electrical

THE WASHINGTON ARCH
Looking up Fifth Avenue at night

Testing Laboratories have conducted detailed investigations of meters for the company, but this merely follows the routine laid down formerly, when expert, disinterested advice was continually brought to bear on the subject.

A few details of design, which have resulted in the installation of newer types of meters on the company's mains, include: A complete design for a side-entrance mechanical meter made on specifications of the company's chief engineer; the substitution of castings for tubing and punching in the construction of the meters; development of insect and dust proof covers; reduction in the weight of the moving element; substitution of enameled, covered wire for silk and cotton and shellac-covered wire to reduce size and weight; the substitution of a paper armature form for that of fiber and brass; gravity counterweights for the regulation of the brushes; considerable reduction in the diameter of the commutator to reduce friction.

The types of direct-current meter at present in active service consist of: house type meters 3 to 4000 amperes, two- and three-wire for both 120 and 240 volt potential, of both bottom and side entrance; switchboard meters of both astatic and four-pole types.

For alternating current, there are: house type, single-phase and polyphase meters for 110 and 220 volt service; switchboard type, single-phase and polyphase meters for 110 to 15,000 volt service.

The meter room proper, was first located in the old Pearl Street station, an uptown branch being

later established at Thirty-ninth Street. In 1892 the Pearl Street and Thirty-ninth Street equipments were consolidated and moved to the southeast corner of the second floor at Duane Street. The mechanical meters were first handled from a departmental office next to the chemical meter department on the eighth floor at Duane Street. In 1904 the main office of the department was moved to the top floor at 117 West Thirty-ninth Street, and, as the work warranted, district offices were established.

The handling of chemical meters required a laboratory for weighing precisely the zinc plates removed each month, for washing and amalgamating the plates, for buffing and polishing to maintain properly the surface of the plates. With the retirement of the chemical meter, facilities for testing mechanical meters were provided, and the laboratory equipment has kept pace with the growth and change in needs, the equipment comprising, in part, motor-generator sets, potential storage batteries, carefully designed test boards, proper checking standards, etc.

Improved test boards have been placed in the laboratory as needed, and complete facilities for verifying the accuracy of the standards have been provided in all district offices. For direct-current testing load, storage batteries with carbon rheostats have practically superseded the water rheostat; while the one-man system of test has been investigated and adopted in preference to the two-man test, for many types of meters and installations.

In 1910 various Murray devices were adopted,

covering installation and testing details in connection with the meters. These devices permitted the complete enclosure and protection of the company's service from the street main to the house side of the meter. They also resulted in standardization and economies in the cost of test, besides eliminating the possibility of error in connection.

The laboratory, office, shops and store-room of the company's meter department are located at 117 West Thirty-ninth Street with district offices at 546 Pearl Street; 45 West Twenty-sixth Street; 314 West Forty-first Street; 171 West One Hundred and Seventh Street and One Hundred and Fortieth Street at Rider Avenue.

The office last mentioned is in the Bronx alternating-current district and is different in its equipment and functions from the Manhattan offices. It is complete in itself, containing the district files of test, laboratory equipment and store-room facilities for alternating-current meters. The Manhattan district offices are reporting centers, equipped with suitable accommodations for the men and proper facilities for verifying the accuracy of portable standards used in customers' premises.

The meter shop at 117 West Thirty-ninth Street is equipped to make necessary repairs and replacements of parts in the meters, both on the company's mains and in the shop; while the meter store-rooms in the direct and alternating-current districts have facilities to maintain a proper stock of meters of all capacities.

The history of the department includes pioneer

work in the investigation of proper bearings for motor meters. Varying compositions of steel, ivory and many grades and kinds of precious stones have been tried as pivots and step-bearings, and as a result, cupped diamonds have been substituted for sapphire bearings in many thousands of meters of certain types and capacities. Many varieties and grades of rare, expensive oil for use on these jeweled bearings have also been investigated.

The meter department at present undertakes acceptance tests and inspection of new meters as they are received from the manufacturer. It provides for proper tests in the laboratory, and for the accuracy of all meters when placed in stock. After installation, inspection and tests establish their continued accuracy in service. After removal and return to the store-room, laboratory tests determine a meter's perfect condition for reissue to a customer's premises.

Laboratory tests and shop repairs now necessitate the handling of over 50,000 meters (in 1911), and service tests and inspections require an organization for making upward of 250,000 service investigations.

The character of the work and the organization of the department presuppose the employment of young men, preference being given to those with high-school training. The department is therefore constantly recruiting men, since an expert tester is a desirable acquisition in other fields of electricity.

Very shortly after the starting of the Pearl Street station in 1882, a test room was equipped and placed

A STUDY IN REFLECTIONS

The Viaduct from New Jersey during the Hudson-Fulton Celebration

in charge of the company's first electrician. It was installed principally for testing the insulation of the underground distributing system, since at that time the maintenance of this insulation was a matter of great concern.

Under the supervision of Mr C S Bradley, and later, Dr S S Wheeler and others, several ingenious special methods were developed for testing the insulation of the underground system, as a whole and while alive. Other devices were invented for locating faults in the system after they had developed. It is interesting to note here that care of instruments, later most important, was not a duty of the test room at first, for no measuring instruments were then employed, and indeed, none were available. While Thomson's reflecting galvanometer was used by telegraphers, and the principle of the electro-dynamometer was fully understood, they had not been developed in commercial form suitable for general electrical measurements. D'Arsonval's moving coil galvanometer, which, as later developed by Dr Weston, revolutionized the electrical measuring art, had not yet been discovered.

In time, other duties were assigned to the test room: first, tests of house wiring in customers' premises, and later, of motors and arc lamps. The force consisted ordinarily of two men, besides the company's electrician who had charge of the department.

The first vice-president, in his annual report to the president of the Edison Electric Illuminating Company, for the year 1892, described the installation

of an electrical testing room and laboratory. Under supervision of the company's chief electrician, it was planned to serve also as a bureau of standards.

The report went on to state: "This has been of great use in testing arc-lights, incandescent lamps, motors and new appliances brought to the attention of the company, and in standardizing all the electrical instruments both portable and otherwise."

The organization of this laboratory as a bureau of standards marked an advance, and this standardization work has since developed into a most important function of the department. The laboratory was fitted with Thomson balances, electro-static voltmeters of the latest type, a Board of Trade standard ohm and other improved apparatus for precise measurements.

At the same time, the general scope of the work was extended to include photometry, for which purpose a dark room and complete photometric equipment were provided, making possible more extensive testing of machinery and appliances.

The standardizing apparatus, although excellent in itself, was not capable of reaching the possible limits of accuracy, since the instruments were clumsy to manipulate even on a comparatively steady commercial current supply. For several years, therefore, these balances and other standards were used only for occasional reference, and dependence was placed upon laboratory pattern, direct-reading instruments. In 1904, owing to storage battery supply and special training of the laboratory assistants, the

standardization work was put upon a systematic basis.

Since 1892 the work of the test department has grown to include: the standardizing laboratory, for the preservation of standards, and calibration as well as repair of instruments; the general laboratory, in charge of all general and technical testing, including that of apparatus and appliances, together with experimental and research work; the station inspection division, for calibration and maintenance of switchboard instruments; and the commercial testing division, controlling tests in customers' premises. Originally, there was no definite division of the work; but, as different features developed, they were organized separately, the commercial testing in 1903, and the station inspection about 1906. It was not until 1908 that the general laboratory was made a special division, because this work, though always important, had previously been done by men drafted at need from the existing force. The pressure inspection division, of more recent growth, has charge of regular inspection of the electrical pressure maintained on the distributing system.

With the enlargement of the test department, its equipment has been steadily extended. From a small corner in the original Pearl Street station, the laboratory was moved to a separate room in the Duane Street building in order to house what was, for that time, an elaborate outfit. In 1903 the laboratory took up an entire floor at 45 West Twenty-sixth Street. In 1910, on account of extending duties

and increasing refinement in standardizing, the laboratory was taken to 92 Vandam Street, a building specially suited to its purposes.

Removed from vibration, stray magnetic fields, dirt and widely varying temperatures, the laboratory equipment was extended to provide complete facilities equal to those of any similar commercial establishment.

The standardizing laboratory now has working standards of the best modern types, and also a wide range of transfer instruments for calibration of portable implements used in meter and general testing. The standards are periodically certified by the Government Bureau of Standards, and by means of a system of checks and records, it is at all times possible to state the accuracy of any portable instrument, in terms of the electrical units legalized by Act of Congress.

The standardizing laboratory is of the greatest importance to the meter department, since the latter obtains its standards of measurement from this source, and, of course, the accuracy of meters tested depends fundamentally upon the accuracy of the standards employed. The operating department is also directly concerned, since station outputs are determined by meters calibrated in the laboratory, and, in addition, the pressure maintained upon the system is determined by means of volt-meters standardized by the laboratory.

The station inspection and pressure inspection divisions are engaged largely in routine work. These divisions follow schedules designed to provide peri-

RIVERSIDE DRIVE ILLUMINATED FOR THE FLEET—1912

odic inspection of station instruments and service pressures.

Besides routine work in collecting data for the contract department, the commercial test division does special testing in customers' premises. These tests vary in importance from those of simple appliances to extensive plant tests, including boilers, engines and compressors, as well as refrigerating plants.

The general laboratory, having charge of important technical experiments and investigations, reflects the progress of the central station industry. Thus, among more important investigations, are the following, in rough chronological order:

Extensive investigations and comparisons of chemical and motor type meters, leading eventually to the adoption of motor meters.

Photometric and life tests of incandescent lamps. Also the testing of returned lamps, leading to a definite practice for handling returned lamps.

The development of protective devices, such as ground detectors. This development followed the extension of the high-tension supply system, as earlier methods proved inadequate.

Extensive tests on the discharge capacities of storage batteries, in relation to their use for stand-by service in substations.

Tests to investigate the many operating features introduced by the concentration of very great generating capacity in the main supply stations. These tests include the short circuit characteristics of generators, the performance of limiting reactances, and many other incidental questions.

Tests on the insulating properties of power cables, and general investigations of dielectrics, for use in such cables.

Research and development work in line and wiring materials, leading to the production of special types of protective devices

such as high- and low-tension fuses, specially adapted to a system of electricity supply where reliability and safety are of utmost importance. Another part of the work consists of the systematic testing of supply materials, machines and miscellaneous apparatus.

In this systematic testing, as in the experimental and research work, much development parallels that of manufacturers, leading to general advance in the quality and usefulness of electrical products.

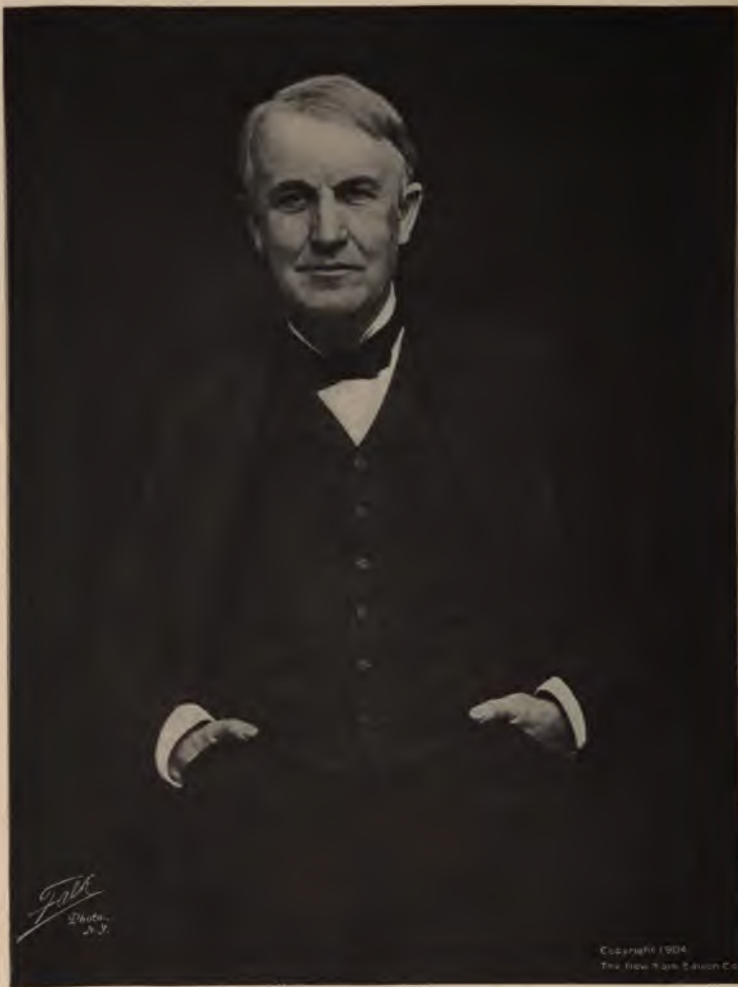
This progressive principle is an exemplification of the company's broad, constructive policy, since work of this character is not directly productive. The department has developed from one or two men, engaged in work which was originally of immediate necessity, into a group of over fifty specially trained employees. The department now possesses extensive plant facilities in a specially adapted building, and its efforts are almost exclusively directed toward improvements and safeguards, and toward the rigorous maintenance of measurement standards.

The New York Edison Company and its Employees

IN the days when the First District system was preparing, a certain comradeship existed among the men concerned in its work. They were all pioneers advancing into a recently discovered but still unexplored country, sure of their ultimate victory, and filled with the determination which met obstacles and surmounted them. Thus they were drawn together by a common interest and a common belief. Today 5000 people are required to carry on the work which this group of enthusiasts began.

It is, however, manifestly difficult, if not impossible, to maintain the same intimate, informal relations in a large body as in a small one. But through all the enormous development of the last fifteen years, a spirit of genuine interest has existed between the executives and all members of the company. This is perhaps due to the fact that many of its officials have won their way to their present positions from the ranks.

Every effort has been made to continue the comradeship of those early days when Mr Edison was himself on the ground and in touch with men on the firing line. An "open door" policy has been con-



THOMAS A EDISON

stantly in force between executives and workers. The latter, even though their relations to the former might be remote, have always been encouraged to appeal to company officials in case of any grievance connected with conditions of employment. Moreover, this door has never been closed to men chafing under apparent lack of opportunity for advancement, or to others wanting guidance in their personal future development. The executives aim continually to make the company a model in its human relations.

Even during the period preceding its present administration, New York's central station system had already begun to provide for the welfare of its workers. Efforts had been made to prevent accidents and to furnish compensation for those occurring; and, while such endeavors—together with all other means for obtaining satisfactory industrial conditions—were by no means so thoroughly worked out as they are today, they serve to show that attention was being paid these matters at a time when such a course was still unusual in large businesses.

All the various methods of the past for maintaining proper working conditions have resulted in The New York Edison Company's present policy toward its employees. This plan of action has many phases and is administered either directly by the company or indirectly through the Association of Employees. It may be summed up under the following heads: accident prevention; care of the injured; efforts for good health among all the company's force; educational incentives; recreational and social opportunities; and the encouragement of thrift. A clearer

understanding of each of these subjects will be obtained from looking into them one by one.

Of paramount importance is the question of accident prevention, and The New York Edison Company believes that its first duty is to reduce, as far as is humanly possible, the risks of the electrical industry. Compared with this, all schemes for compensating the injured or their families are lame endeavors.

In accordance with this belief the company has given particular attention to the safeguarding of machinery, to the establishment of a system of warning signals and to the promulgation of stringent rules designed to prevent accidents through inadvertence or ignorance. Since the greatest source of danger is of course the use of high-tension apparatus, great care has been taken to cover all the vital parts of such machinery, and so well has this been effected that serious accidents are rare. During the year 1911 there was not a single death from injury among all the Edison employees, and of that year's accidents only 11.11 per cent were due to electrical causes.

At generating stations an elaborate system of supervision and notification is in force. For instance, switches which control the generators are in separate compartments. These are locked, carefully numbered, and the voltage is recorded. To use a switch, the operator must be accompanied by some one who unlocks the door leading to it. All rotary converters are equipped with hand-rails, and rubber mats are also provided. Each operator is given a copy

of the "Rules for the Government Employees Operating and Handling High-tension Apparatus," for which he signs a receipt. Besides, machines are regularly inspected and a sharp lookout is kept for flaws in the transmission or transforming system. In addition, the touching of dangerous apparatus is done only with rubber gloves which have been tested by an electrical pressure of 10,000 volts.

So much for the warding off of accidents. If, in spite of precautions, an employee is hurt the next question is the treatment of his injury. Previous to 1905 the company carried a large industrial accident policy; but, becoming convinced that this did not result in sufficiently broad consideration for the men, it took upon itself the care of sick or injured employees. Three physicians, versed in the treatment of accident cases, were secured, and a plan of procedure was laid out.

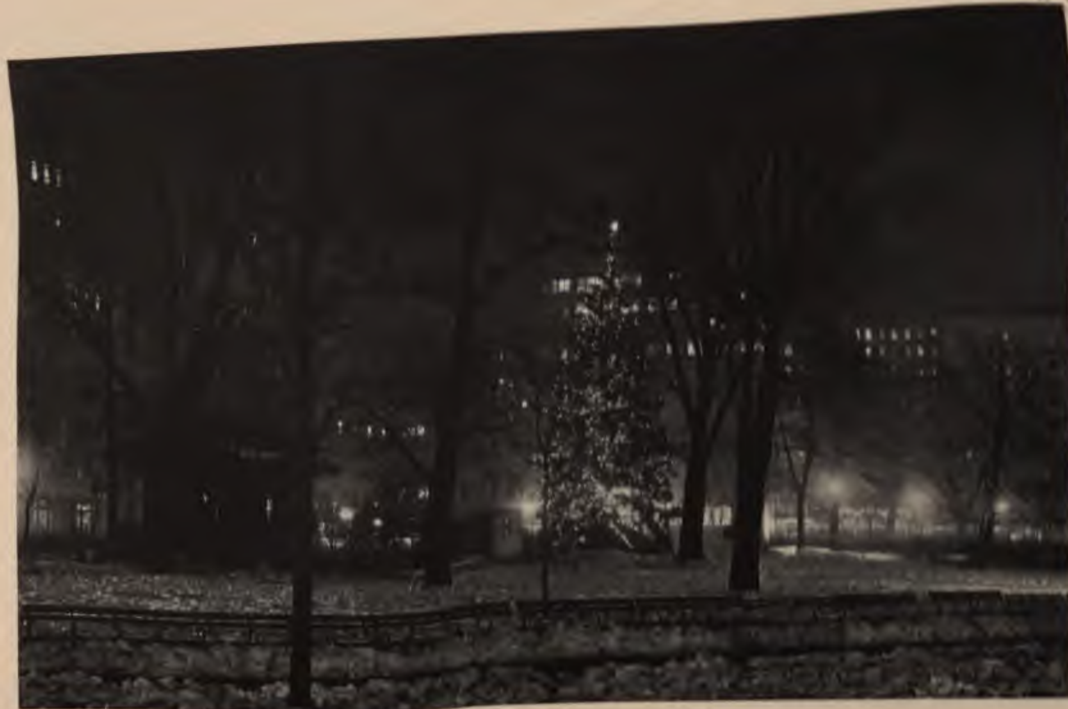
Under this arrangement, if a person is very slightly hurt he is treated at a medical cabinet kept for the purpose. If his trouble is more serious he is sent to a doctor who examines him, treats him and sends in a report of his case. The man is then returned to "full duty" or "partial duty" or given sick leave, according to the physician's judgment, and a complete account of the accident and its causes is sent in by the foreman as well as by the medical attendant. All such records are preserved and from them the company's statistics are compiled. In 1911, 1412 injuries were reported, of which more than half were so slight that the workmen lost no time, and 246 were "off duty" from one to three days. A large

proportion of the remainder were incapacitated for not more than two weeks and the three gravest cases required from fifteen to eighteen weeks for recovery. Of the total number of accidents, it was found that the victims themselves were responsible for 87.4 per cent; fellow-employees for 6.87 per cent; outside agents for .70 per cent; and the company for 5.39 per cent.

It goes without saying that the expense of all treatment for injuries is met by the company, and that a man who loses time from such a cause does not lose wages. Workmen who have been wholly or partially crippled are put upon the "disability payroll," and in case of their death their widows or dependents receive the same sum which the men would have received had they been totally incapacitated.

In close association with caring for the injured come the arrangements for treating any Edison employee who is ill. He or she may have the services of a company doctor without expense, while full salary is paid until the patient recovers. This has sometimes been done for as long as a year or more. It is customary always to grant applications for "time off" to keep dentists' or oculists' appointments, it being deemed wisest as well as kindest to encourage the entire working force to be in the best physical trim. For this reason, also, the company urges its members to take up athletics, but this question will be dealt with later under its proper head.

Having provided, as far as possible, for the physical well-being of those it employs, the Edison Company strives to give them educational opportunities,



EVERYBODY'S CHRISTMAS TREE

Madison Square—1912

to the end that they may be fitted for promotion and that the organization's business may be conducted more smoothly. This is done for the most part in two ways: through the Association of Employees, and through the company's commercial school.

The Association of Employees has nearly 2000 members who each pay dues of $2.60 a year. This gives it funds to support many enterprises in which it is materially helped by The New York Edison Company. Among the institutions of this association is a technical school. The scope of the course is laid out by the employees, but expenses are met by the company, which provides instructors and furnishes the laboratory where classes meet. The first year's training is intended for beginners and provides an excellent grounding in the principles of electricity. This is followed by a second year, going more deeply into the subject, while the third course deals especially with the study of alternating-current machinery.

In 1911 a school to provide other than technical training was begun and, since attendance is compulsory, employees are allowed time for it during the company's hours. It is designed to acquaint members of various bureaus with the system of the entire company, to show them the interrelation of different departments and to increase their interest and intelligence with regard to their work. It is really a school of salesmanship and is intended to be especially valuable to all employees who act in any way as go-betweens for the company and the general public. There are four courses, the first having as

its subject "Elements of Central Station Business-Getting." Lectures are delivered on points in this connection, such as: "Courtesy—the Greatest Industrial Asset"; "The Value of Right Thinking"; "Education—What to Learn"; and "Six Steps in

THE LIBRARY OF THE NEW YORK EDISON COMPANY
Drawn by Vernon Howe Bailey

Salesmanship." In all, twenty-six of these talks are given, nine of them being based on the "Electrical Solicitor's Handbook" of the National Electric Light Association, six of them relating to fundamental electricity and the rest taking up miscellaneous topics.

Course II concerns "Hygiene, Health and Recreation, and Elements of Psychology." Some of its

lectures are on "Making the Most of Your Vacation"; "Helps for Better Health"; "What is Psychology?"; "The Human Element in Business."

Course III deals with "Basic Principles of Salesmanship and their Relations to Business-Getting." Outsiders of note in their own professions speak to the employees on many problems of salesmanship.

Course IV is devoted to the "Policies and Organization of The New York Edison Company," and representatives of the company's different departments explain subjects of interest, such as "Contracts," "Commercial Engineering," "Central Station Service—Its Advantages over Isolated Plants."

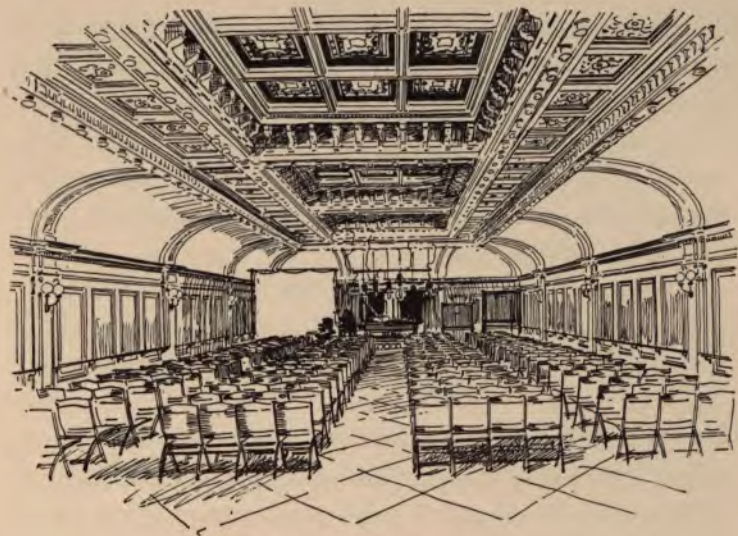
Employees who attend the lectures are required to hand in written summaries. Their work is graded and careful records are kept of the manner in which it is done. Afterward, this information is used in questions of promotion. Although the school has been in existence only about a year, 250 men and women have been enrolled, this being about 75 per cent of the membership of the contract and inspection department. Of these, seventy-six have gained certificates for having completed Courses II, III, and IV, since Course I is only required of newcomers to the company. All employees who come in contact with the general public are expected to attend one or more of the courses and eventually to get certificates. The New York Edison Company was the first electrical organization to plan a school of this sort, and its success had emboldened other corporations to develop similar methods of instruction.

The company library at 44 West Twenty-seventh Street might be added as another educational opportunity, since periodicals and works on technical subjects are there provided for all employees, while *The Edison Weekly* regularly contains a digest of recent articles on electrical and scientific subjects. This "house organ," begun in the contract and inspection department a few years ago with a circulation of about 300, is now sent regularly to 2775 employees while the demand for it is steadily increasing.

The old saying about "all work and no play" is today established as a psychological fact, and no scheme for the welfare of a large working force would be complete without some provision for athletics as well as for sociability.

The Employees' Association supports a baseball team and arranges games with semi-professionals and with the teams of other electrical companies, while in the winter bowling takes the place of outdoor sports. Then there are the association's monthly meetings—partly devoted to business, partly to pleasure—several of which each year are arranged especially for the welcome of women members. In addition, there is an annual entertainment as well as a summer picnic. Both of these events are so popular as to be not only self-supporting but also lucrative, helping to fill the association's treasury.

The New York Companies' Section of the National Electric Light Association also holds monthly entertainments and meetings besides its yearly ex-



THE EDISON AUDITORIUM
Drawn by Vernon Howe Bailey

cursion and, to encourage members of the Association of Employees to enter this other body, the Edison Company pays one half the dues of all who join.

Last, but not least, in promoting the well-being of workers comes the question of individual financial aid and reward. The employees, through their association, maintain a death benefit fund; and to each $150 paid on the decease of a member, the company adds $100. During the year 1912 a Savings and Loan Association was organized, of which the company assumes all running expenses and guarantees the safety. Depositors are paid 6 per cent interest, and money is lent at the same rate to employees who wish to build homes. This is done

in the hope of developing thrift, it being felt that a man's first step toward independence is the owning of his own home. Although the Savings and Loan Association has only been in active operation a few months $17,000 have already been entered on its books, and three persons have been enabled to become their own landlords.

In thus having regard for the safety, health and happiness of the people whom it employs The New York Edison Company has done away with much friction in the mechanism of daily work. Strikes, for instance, have been almost unknown in recent years; but the company looks not only to eliminate strikes, but to do away with indifference and carelessness among all its workers. For without intelligent, interested effort on the part of every one from the office boy up, good service to the public cannot result.

Statistics

A Corporate Statement

THE New York Edison Company is successor to the Edison Electric Illuminating Company of New York and the New York Gas, Electric Light, Heat and Power Company. The consolidation of these two corporations was consummated on May 1 1901.

From the time of its organization, the Edison Electric Illuminating Company of New York had only three chief executives. Its first president was Dr Norvin Green, elected on December 20 1880, who continued to serve until December 11 1883. At the end of Dr Green's term the company had approximately 900 horse-power in station equipment, and was serving 513 customers who maintained 10,297 incandescent lamps rated at 16 candle-power.

The second president, Mr Spencer Trask, was elected on December 11 1884 and remained in office more than fourteen years, resigning on May 26 1899. This period of administration saw a growth to 24,200 horse-power in station machinery, to 10,400 customers, and the equivalent of 980,000 incandescent lamps of 16 candle-power.

Mr Anthony N Brady, the third president,

elected on May 18 1900, was chief executive of the corporation until its termination and merging with the present company on May 1 1901. With the organization of The New York Edison Company, Mr Brady was chosen president, his term of office continuing unbroken to the present time. This administration, beginning with 36,290 horse-power in station equipment, has developed it to no less than 400,000 horse-power, while during the same years the number of customers has increased from about 18,000 in 1901 to today's aggregate represented by 170,000 meters. There has been a corresponding growth in current distributed, rising from approximately 1,625,000 50-watt equivalents in 1901 to the present total of 11,000,000 50-watt equivalents.

This makes The New York Edison Company by far the largest corporation in existence whose service is devoted entirely to the commercial light and power field. Its extraordinary growth is perhaps better indicated by the charts in this chapter, their shadings representing the wonderful electrical development of New York City during the present corporation's existence.

The incorporators of the Edison Electric Illuminating Company were: Mr T R Edson, Mr James H Banker, Mr R L Cutting, Jr, Mr Egisto P Fabbri, Mr José F di Navarro, Mr Nathan G Miller and Mr G P Lowry. The first board of directors, which was elected on December 17 1880, added Dr Norvin Green, Mr Robert M Gallaway, Dr James O Green, Mr Henry Villard, Mr T A Edison and Major Sherburne B Eaton.

STATISTICS

The present directors of The New York Edison Company are: Mr George F Baker, Mr Anthony N Brady (president), Mr Nicholas F Brady (first vice-president), Mr George B Cortelyou, Mr Harrison E Gawtry, Mr Lewis B Gawtry (secretary), Mr Thomas E Murray (second vice-president), Mr Edgar Palmer, Mr William Rockefeller, Mr John W Sterling and Mr Frank A Vanderlip.

Growth in Customers and Equivalents

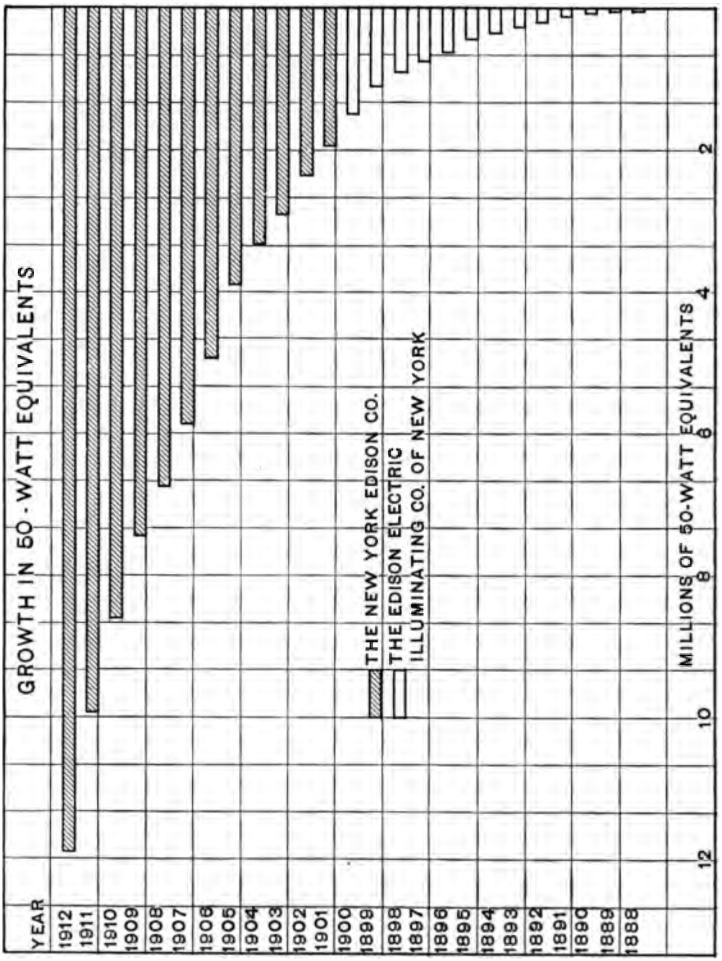
Manhattan and Bronx

Year	Number of Customers	50 Watt Equivalents
September 4 1882		
October 1	59	1,284
November 1	94	1,704
December 1	203	3,144
January 1 1883	231	3,477
February 1	302	4,131
March 1	324	4,331
April 1	361	4,884
May 1	386	5,574
June 1	410	6,466
July 1	436	7,429
August 1	443	7,946
September 1	455	8,218
October 1	472	8,573
November 1	508	10,164
December 1	513	10,297
December 31, 1888	710	16,377
December 31, 1889	1,213	45,615
December 31, 1890	1,698	73,684
December 31, 1891	2,875	122,895

Growth in Customers and Equivalents

Manhattan and Bronx

Year	Number of Customers	Number of Meters	50 Watt Equivalents
December 31, 1892	4,344		196,932
December 31, 1893	5,154		273,361
December 31, 1894	5,877		340,784
December 31, 1895	6,675		425,823
December 31, 1896	7,898		613,991
December 31, 1897	8,711		756,438
December 31, 1898	9,990		891,614
December 31, 1899	11,015		1,102,121
December 31, 1900	16,349		1,473,807
December 31, 1901		28,036	1,928,090
December 31, 1902		33,691	2,343,721
December 31, 1903		40,230	2,851,463
December 31, 1904		46,961	3,320,310
December 31, 1905		56,572	3,878,666
December 31, 1906		68,990	4,923,986
December 31, 1907		80,809	5,856,166
December 31, 1908		90,283	6,729,926
December 31, 1909		104,449	7,422,649
December 31, 1910		121,853	8,584,725
December 31, 1911		144,018	9,922,562
August 31, 1912		157,658	10,672,042


GROWTH IN 50-WATT EQUIVALENTS
THE NEW YORK EDISON CO.
THE EDISON ELECTRIC ILLUMINATING CO. OF NEW YORK
MILLIONS OF 50-WATT EQUIVALENTS
YEAR
1912
1911
1910
1909
1908
1907
1906
1905
1904
1903
1902
1901
1900
1899
1898
1897
1896
1895
1894
1893
1892
1891
1890
1889
1888
12
10
8
6
4
2

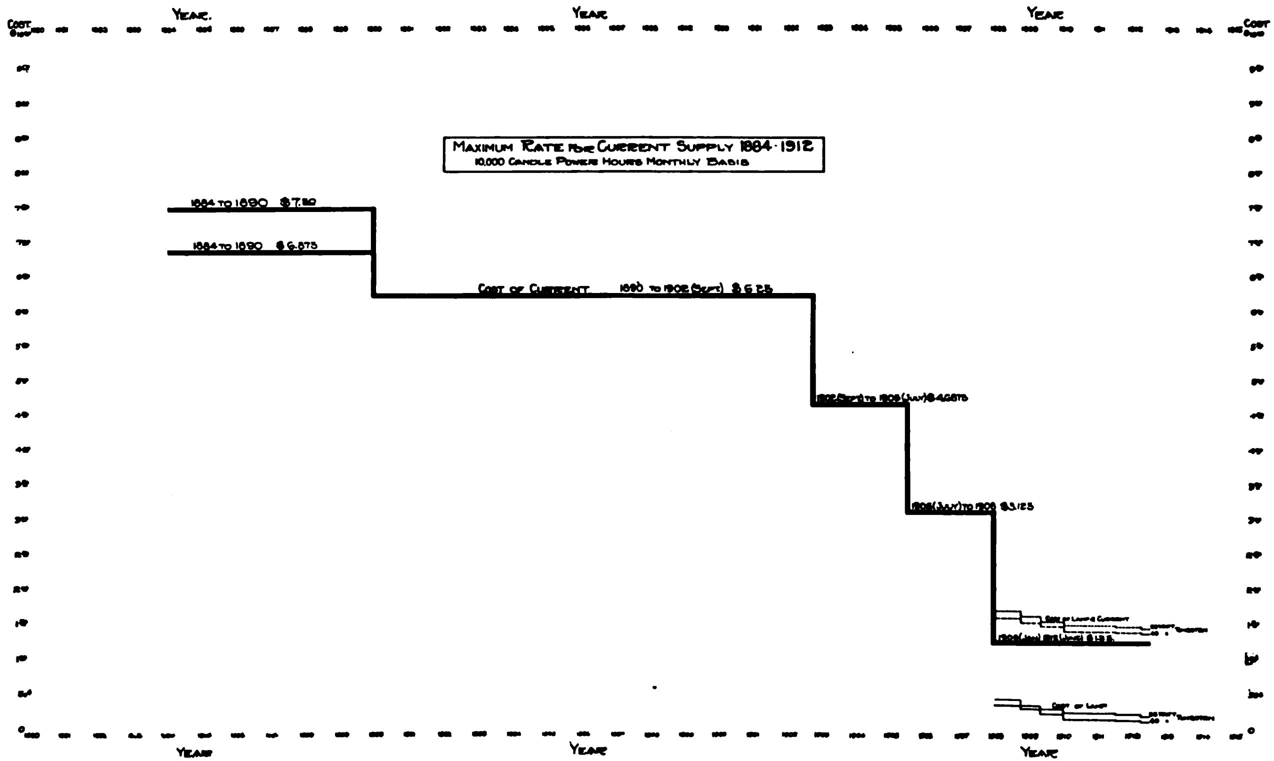
Mileage, by Years, of the Edison Underground System

Existing Dec. 31	Two-Wire System		Three-Wire System		Transmission Feeders Miles	Total Miles	Increase
	Mains Miles	Feeders Miles	Mains Miles	Feeders Miles			
1881	No Re	cord	....	....	....	No Record	....
1882	9.50	4.00	....	....	....	13.50	....
1883	No Re	cord	....	....	....	No Record	....
1884	No Re	cord	....	....	....	No Record	....
1885	No Re	cord	....	....	....	No Record	....
1886	No Re	cord	....	....	....	No Record	....
1887	No Re	cord	19.95	16.56	....	50.01 (?)	36.51
1888	No Re	cord	22.79	17.93	....	54.22 (?)	4.21
1889	10.90	4.54	30.92	21.06	....	67.42	13.20
1890	8.93	4.43	63.04	34.26	....	110.66	43.24
1891	4.80	4.21	89.76	42.66	....	141.43	30.77
1892	2.39	4.18	111.86	54.05	....	172.48	31.05
1893	.74	2.53	122.04	62.11	....	187.42	14.94
1894	.39	.13	126.03	65.28	....	191.83	4.41
1895	.24	....	133.92	68.76	....	202.92	11.09

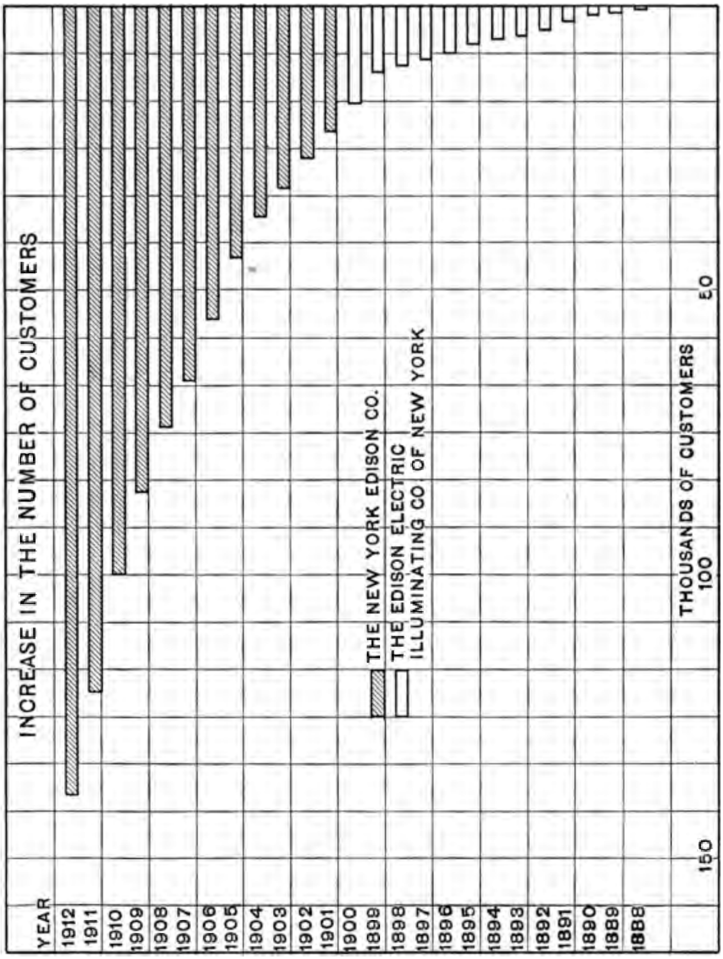
1896	.17	....	138.49	70.67	....	209.33	6.41
1897	.15	....	144.49	77.15	....	221.79	12.46
1898	.15	....	156.15	80.16	3.26	239.72	17.93
1899	.15	....	179.23	85.00	38.34	302.72	63.00
1900	.15	....	225.49	98.90	49.92	374.46	71.74
1901	.15	....	238.45	108.49	72.88	419.97	45.51
1902	.15	....	278.31	124.15	84.63	487.24	67.27
1903	....	....	334.67	152.82	107.44	594.93	107.69
1904	....	....	379.19	183.31	135.54	698.04	103.11
1905	....	....	429.02	206.59	159.17	794.78	96.74
1906	....	....	483.79	225.84	183.58	893.21	98.43
1907	....	....	511.80	243.15	205.14	960.09	66.88
1908	....	....	532.88	249.28	236.70	1,018.86	58.77
1909	....	....	560.94	271.69	281.57	1,114.20	95.34
1910	....	....	592.51	288.15	324.22	1,204.88	90.68
1911	....	....	624.96	305.19	361.91	1,292.06	87.18
*1912	....	....	646.48	319.70	384.00	1,350.25	58.19

* To September 4, eight months only.

NOTE.—Records of the First District for the years 1883, 1884, 1885, 1886, 1887 and 1888 were lost in the fire which destroyed the original Pearl Street station in 1890.



MAXIMUM RATE FOR CURRENT SUPPLY 1884-1912
10,000 CANDLE POWER HOURS MONTHLY BASIS
YEAR
YEAR
YEAR
COST
COST
1884 TO 1890 $7.50
1884 TO 1890 $6.875
COST OF CURRENT
1890 TO 1902 (SEPT) $6.25
1902 (SEPT) TO 1906 (JULY) $4.6875
1906 (JULY) TO 1909 $3.125
YEAR
YEAR
YEAR


INCREASE IN THE NUMBER OF CUSTOMERS
THE NEW YORK EDISON CO.
THE EDISON ELECTRIC ILLUMINATING CO. OF NEW YORK
YEAR
1912
1911
1910
1909
1908
1907
1906
1905
1904
1903
1902
1901
1900
1899
1898
1897
1896
1895
1894
1893
1892
1891
1890
1889
1888
THOUSANDS OF CUSTOMERS
150
100
50

Mileage of the Two-Wire System in the First District, Showing How it was Superseded by the Three-Wire System

December 31, 1889	15.24	Miles
December 31, 1890	13.16	"
December 31, 1891	8.81	"
December 31, 1892	6.37	"
December 31, 1893	3.2765	"
December 31, 1895	0.24	"
December 31, 1898	0.15	"

From Annual Reports of the Edison Electric Illuminating Company

Most Northern Point of the Edison System at Various Stages of Development

1883	Nassau Street near Park Row
1889	Fifty-ninth Street
1890	Fifty-ninth Street
1891	Sixty-sixth Street
1892	Seventy-ninth Street
1893	Seventy-ninth Street
1897	Eighty-seventh Street
1898	Ninety-fifth Street
1902	The Bronx
1912	Edison Service in practically every street of Manhattan and the Bronx

STATISTICS

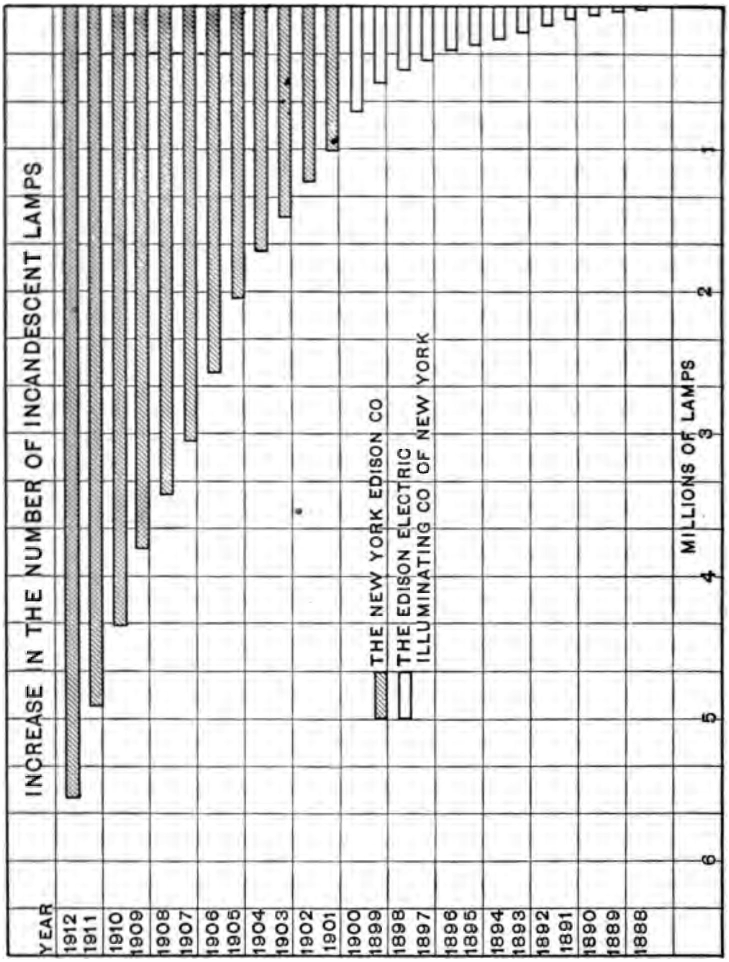
Average Life of Lamps during Early Years of Edison Service

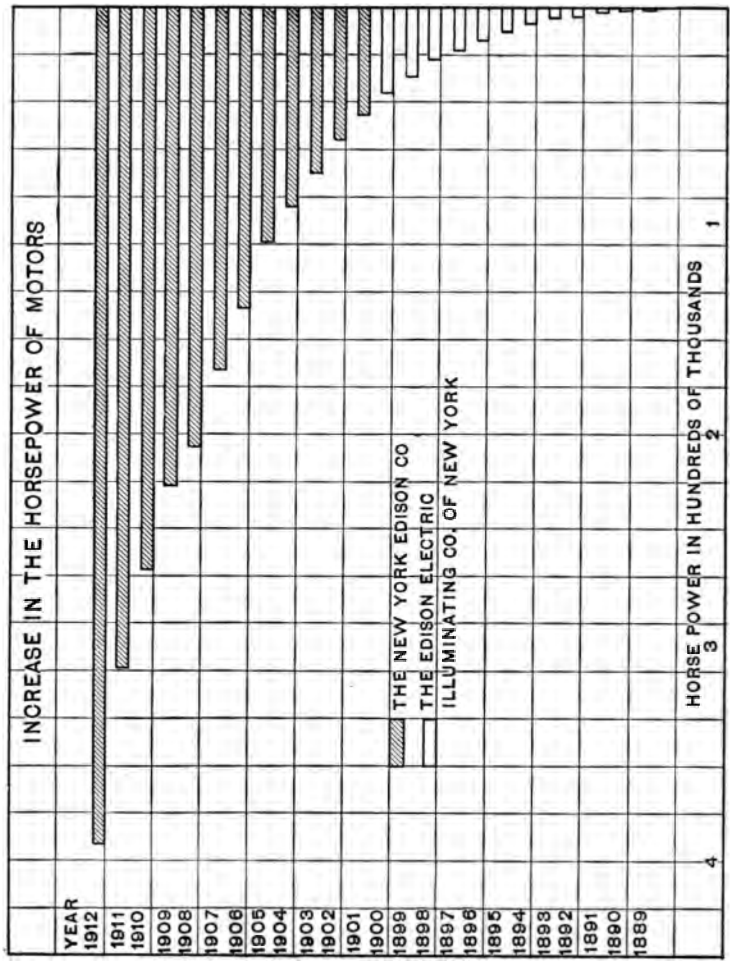
	1884	1885	1886
January	400 hours	1084 hours	1227 hours
February	523 "	1075 "	1091 "
March	349 "	1032 "	996 "
April	448 "	1047 "	998 "
May	400 "	838 "	1244 "
June	389 "	939 "	1423 "
July	502 "	1009 "	1505 "
August	553 "	924 "	1235 "
September	727 "	948 "	1504 "
October	730 "	884 "	1478 "
November	914 "	1029 "	1623 "
December	832 "	1347 "	1462 "

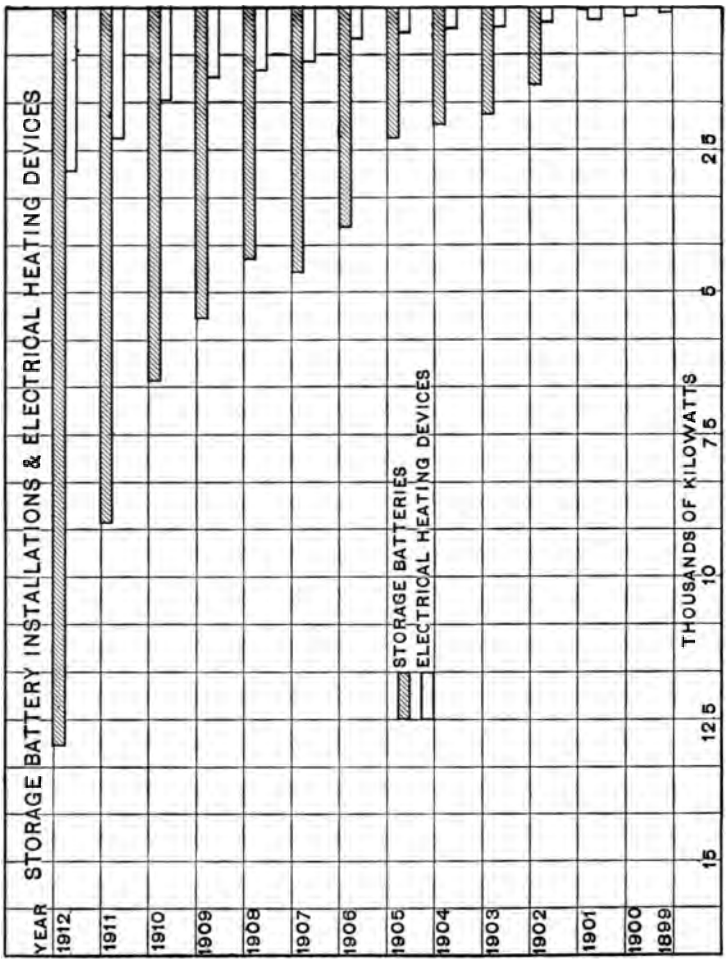
From the Annual Report of the Edison Electric Illuminating Company for 1886

The Company Payroll

	No. of Employees	Total Annual Payroll
Week ending		
August 24 1882 . . .	78	$71,000.80
30 years after		
August 24 1912 . . .	5732	$5,167,847.88


INCREASE IN THE NUMBER OF INCANDESCENT LAMPS
YEAR
1912
1911
1910
1909
1908
1907
1906
1905
1904
1903
1902
1901
1900
1899
1898
1897
1896
1895
1894
1893
1892
1891
1890
1889
1888
THE NEW YORK EDISON CO
THE EDISON ELECTRIC ILLUMINATING CO OF NEW YORK
MILLIONS OF LAMPS
1
2
3
4
5
6


INCREASE IN THE HORSEPOWER OF MOTORS
YEAR
1912
1911
1910
1909
1908
1907
1906
1905
1904
1903
1902
1901
1900
1899
1898
1897
1896
1895
1894
1893
1892
1891
1890
1889
THE NEW YORK EDISON CO
THE EDISON ELECTRIC
ILLUMINATING CO. OF NEW YORK
HORSE POWER IN HUNDREDS OF THOUSANDS
4
3
2
1


STORAGE BATTERY INSTALLATIONS & ELECTRICAL HEATING DEVICES
YEAR
1912
1911
1910
1909
1908
1907
1906
1905
1904
1903
1902
1901
1900
1899
STORAGE BATTERIES
ELECTRICAL HEATING DEVICES
THOUSANDS OF KILOWATTS
2.5
5
7.5
10
12.5
15

STATISTICS

Dates of Opening Various Stations

255–257 Pearl Street	1882
60 Liberty Street (annex station)	1886
39th Street—West	1888
26th Street	1888
Produce Exchange Annex	1890
Duane Street	1891
53d Street	1893
12th Street	1895
Bowling Green	1896
83d Street	1898
Crosby Street	1898
Gold Street	1899
121st Street	1899
Vandam Street	1900
Horatio Street	1900
84th Street	1900
123d Street	1900
140th Street	1900
Riverdale	1900
Waterside No 1	1901
Clinton Street	1903
27th Street—West	1903
107th Street	1904
Water Street	1906
Waterside No 2	1906
39th Street—East	1906
60th Street	1906
16th Street	1907
64th Street	1907
Fordham	1909
Gimbel Building	1910
Blackwell's Island	1910
41st Street—West	1910

Data on Feeders of First District as Originally Used on September 4 1882

Number of feeder	Number of tube and copper	Length of each feeder from catch-box to elbow in front of station curb	Length of piece No 3 copper from elbow through cellar wall	Equivalent length in main copper of feeder	Length of piece, No 2 ¾ copper from cellar to station	Equivalent length in main copper of feeder	Length of each feeder from elbow to station main	Equivalent length of this part in main copper of respective feeder	Length of each feeder from catch-box to station main	Equivalent length of each feeder from catch-box to station main	Equivalent length in No 3 copper per 262,951 circular mils	Carrying capacity compared with No 3 as unity	Carrying capacity compared with No 18 as unity	Feeder terminus at catch-box at intersection of
1	1½	1720	7′9″	38′	57′ 8″	151′ 2″	65′ 5″	189′ 2″	1785	1909	387	1.129	.7623	William and Wall
2	1½	1520	3′6″	16′ 4″	61′ 6″	161′ 3″	65′ 0″	177′ 7″	1585	1698	344	1.270	.8575	Nassau & Maiden Lane
3	2	1315	3′2″	10′ 7″	62′ 8″	109′ 4″	65′10″	119′11″	1381	1435	437	1.000	.6750	Nassau and John
4	2½	900	2′8″	6′10″	62′ 7″	85′ 0″	65′ 3″	91′10″	965	992	388	1.126	.7605	William and John
5	1½	1437	3′4″	16′ 4″	65′ 0″	170′ 5″	68′ 4″	186′ 9″	1505	1624	322	1.357	.9162	Nassau and Fulton
6	2	1182	2′8″	8′ 9″	66′ 2″	115′ 6″	69′ 0″	124′ 3″	1251	1306	398	1.098	.7412	Dutch and Fulton
7	1½	1580	4′8″	23′ 0″	48′ 0″	125′10″	52′ 8″	148′10″	1633	1729	351	1.245	.8405	Nassau and Ann
8	1½	1767	6′0″	29′ 7″	47′ 3″	123′10″	53′ 3″	153′ 5″	1820	1920	389	1.123	.7584	Nassau and Beekman
9	2	1195	6′10″	22′ 5″	57′11″	101′ 0″	64′ 9″	123′ 5″	1260	1318	400	1.092	.7375	Pearl and Wall
10	2¾	647	6′0″	11′ 3″	56′ 6″	56′ 6″	62′ 6″	67′ 9″	710	715	380	1.150	.7763	Pearl and Maiden Lane
11	2¾	710	4′6″	8′ 5″	67′ 2″	67′ 2″	71′ 8″	75′ 7″	782	786	418	1.045	.7041	Gold and Platt
12	2½	975	5′4″	13′ 7″	63′10″	86′ 8″	69′ 2″	100′ 3″	1044	1075	421	1.038	.7007	William and Platt
13	2¾	725	4′0″	7′ 6″	58′ 0″	58′ 0″	62′ 0″	65′ 6″	787	790	420	1.041	.7024	Gold and Fulton
14	1½	1382	6′8″	32′ 9″	47′ 2″	123′ 8″	53′10″	146′ 7″	1436	1529	310	1.410	.9516	William and Beekman
15	2	1077	7′4″	24′ 0″	46′ 0″	80′ 3″	53′ 4″	104′ 3″	1130	1181	360	1.214	.8194	Gold and Beekman
16	2½	1015	5′4″	13′ 7″	46′ 0″	63′ 6″	58′ 1″	77′ 1″	1058	1093	428	1.021	.6893	Gold and Beekman
17	2½	937	20′4″	51′10″	52′ 6″	71′ 4″	72′10″	123′ 2″	1010	1060	415	1.053	.7108	Front and Fletcher
18	3	230	20′4″	20′ 4″	44′ 8″	44′ 8″	65′ 0″	65′ 0″	295	295	295	1.481	1.000	Water and Fulton
19	3	100	19′0″	19′ 0″	48′ 0″	48′ 0″	67′ 0″	67′ 0″	167	167	167	2.616	1.776	Pearl and Fulton
20	2¾	630	19′8″	37′ 0″	43′ 0″	43′ 0″	62′ 8″	80′ 0″	693	710	377	1.159	.7825	Water and Beekman

Total 22,297 feet = 4.22 miles.

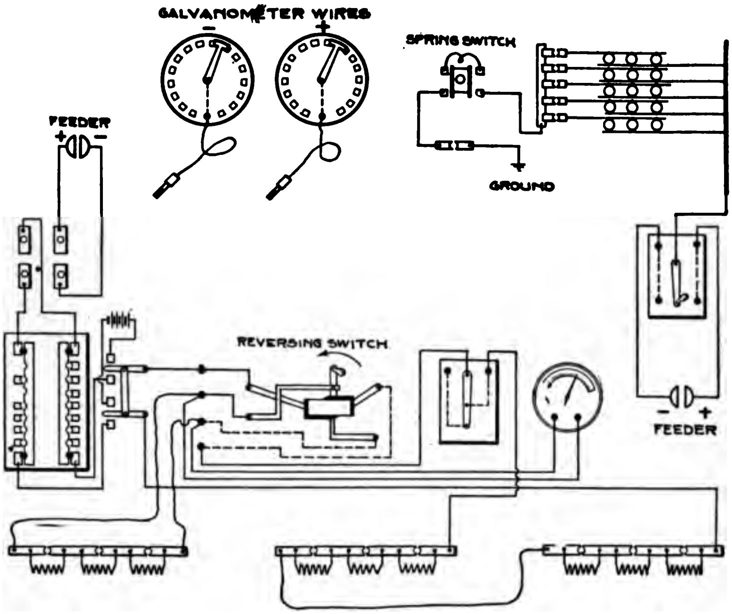


DIAGRAM OF APPARATUS FOR LOCATING GROUNDS IN EARLY DAYS OF EDISON SERVICE

Standard Sizes of Feeders and Mains for the Original First District System

Size of Tubes No.	Area of One-Conductor Circular Mils	Maximum Current	Standard Outside Diameter Inches
1	1,639,890	1,400	3½
1½	1,296,419	1,100	3¼
2	862,976	760	3
2½	671,362	660	2⅞
2¾	491,541	570	2½
3	262,951	370	2¼
4	182,884	300	1.09
5	107,289	220	1.31
6	66,581	170	1.31
7	33,015	100	1.05

Figures Based on Data from Mr John Kruesi

No of Feeder	Length of each from Station Main to Catch-box in Street	Equivalent Length in Feeder Copper	Equivalent Length in No 3, 262,951 Circular Mils	Feeders Arranged Equipotentially: No of Feeder	Feeders Arranged Equipotentially: Proportional Resistance, 1 foot No 3 taken as unity	Feeders Arranged Equipotentially: Capacity compared to No 14, with Load of 100
1	2,205	2,241	454	19	180	172
2	2,365	2,478	503	14	310	100
3	1,591	1,645	501	18	320	97
4	965	992	388	5	322	96
5	1,505	1,624	322	7	351	88
6	1,251	1,306	398	15	360	86
7	1,633	1,729	351	20	374	83
8	1,820	1,920	389	10	380	82
9	1,260	1,318	400	4	388	80
10	710	715	380	8	389	80
11	782	786	418	6	398	78
12	1,684	1,573	616	17	400	77
13	787	790	420	9	400	77
14	1,436	1,529	310	11	418	74
15	1,130	1,181	360	13	420	74
16	1,058	1,093	428	16	421	74
17	970	1,020	400	1	454	68
18	320	320	320	3	501	62
19	180	180	180	2	503	62
20	687	704	704	12	616	50

The Edison Electric Illuminating Company and The New York Edison Company

Year	Customers	Meters Set	No of Incandescent Lamps	No of Arc Lamps	Heating Appliances (K W)	Storage Battery, etc. (K W)	H P Motors	50 Watt Equivalents
Sept. 4, 1882	......	......	......	......	......	......	......	......
Dec. 1, 1882	203	......	3,144	......	......	......	......	3,144
Dec. 1, 1883	513	......	10,297	......	......	......	......	10,297
Dec. 1, 1884	......	......	......	......	......	......	......	......
Dec. 1, 1885	......	......	......	......	......	......	......	......
Dec. 1, 1886	......	......	......	......	......	......	......	......
Dec. 1, 1887	......	......	......	......	......	......	......	......
Dec. 31, 1888	710	......	16,377	......	......	......	......	16,377
Dec. 31, 1889	1,213	......	39,815	110	......	......	470	44,515
Dec. 31, 1890	1,698	......	64,174	254	......	......	697	73,684
Dec. 31, 1891	2,875	......	94,485	841	......	......	2,000	122,895
Dec. 31, 1892	4,344	......	142,492	1,637	......	......	3,807	196,932
Dec. 31, 1893	5,154	......	192,691	2,538	......	......	5,529	273,361
Dec. 31, 1894	5,877	......	234,494	3,014	......	......	7,616	340,784
Dec. 31, 1895	6,675	......	271,123	3,741	......	......	12,046	425,823
Dec. 31, 1896	7,898	......	309,369	4,114	......	......	15,953	613,991
Dec. 31, 1897	8,711	......	382,291	5,467	......	......	19,380	756,438
Dec. 31, 1898	9,990	......	443,074	5,660	......	......	24,438	891,614
Dec. 31, 1899	11,015	......	546,094	6,749	86	......	32,454	1,102,121
Dec. 31, 1900	16,349	....	741,635	14,286	166	......	40,719	1,473,807
Dec. 31, 1901	......	28,036	1,008,439	15,706	226	30.5	50,995	1,928,090
Dec. 31, 1902	......	33,691	1,234,043	16,481	251	1,386	62,377	2,343,721
Dec. 31, 1903	......	40,230	1,481,638	19,975	339	1,880	78,683	2,851,463
Dec. 31, 1904	......	46,961	1,723,482	25,437	369	2,076	93,441	3,320,310
Dec. 31, 1905	......	56,572	2,058,060	27,627	428	2,324	109,371	3,878,666
Dec. 31, 1906	......	68,990	2,575,652	35,234	570	3,859	141,407	4,923,986
Dec. 31, 1907	......	80,809	3,057,294	40,679	921	4,669	169,588	5,856,166
Dec. 31, 1908	......	90,283	3,429,266	43,123	1,096	4,420	203,962	6,729,926
Dec. 31, 1909	......	104,449	3,813,889	40,985	1,230	5,486	224,391	7,422,649
Dec. 31, 1910	......	121,853	4,342,933	40,410	1,589	6,571	263,529	8,584,725
Dec. 31, 1911	......	144,018	4,912,428	39,329	2,283	9,024	309,187	9,922,562
Dec. 31, 1912	......	169,075	5,555,854	41,428	2,805	12,983	392,704	11,886,692

Electricity

"Let there be light,"
The Wizard cried,
And straight the night
Was glorified,
While arc and incandescent blazed
Till all the world looked on, amazed
And dazzled by the splendid light
Which swept the shadows of the night
Away
And turned the darkness into day;
Lit up the city,
Flashed its gleams
Along the pathways of man's dreams
Of hidden power, that he might see
The trail to untold energy.
Ho, Light and Power,
The guide and force
Which measure and control the course
Of all activities, you stand
Twin souls of progress in a land
Which leads
In meeting man's material needs.
The wayside and the farm
Have felt your strength and charm,
But in the city, at the heart
Of concentration, there your part

ELECTRICITY

Means everything; there you give
The touch that makes man truly live,
And what you are today is nought
Compared with wonders to be wrought
In days to come when you attain
The fullness of your promised gain.
And yet how young you are!
How brief the space
From weakling to the giant's place
Where now you mark
Attainment by a flashing spark!
Born with the earth,
There was no meaning to your birth
Until a Wizard wisdom saw and knew
The destiny of power in you,
And, from your birthplace and your grave,
Raised you, man's master and his slave.
How young you are,
And yet how you have grown
Essential to mankind!
And when the end is known,
The substance and the mind,
Perhaps, no one now knows,
It may be you through which life's current flows.

W J Lampton

Looking Forward

THE central station system in New York today stands an actual, tangible embodiment of visions realized; and not the visions of one man alone but those of all the students of an unknown force who have given their thoughts, energies and hopes, sometimes with apparent unsuccess, to the forwarding of electricity on its mission to mankind. But as in nature everything is in a state of becoming, so the achievements thus recorded serve only as milestones marking the long route of progress.

What, then, are the possibilities for the further growth of Edison Service? Summed up in two phrases they may be termed: greater internal advance, and more complete general usefulness.

Development, like charity, begins at home, and in order to respond adequately to the needs of a city, an industry must strive always to keep its equipment up to the highest standard. Now this equipment includes not only machines, but people and ways of dealing with them. As a company keeps abreast of all inventions for mechanical betterment, adopting such as suit its purposes, so a constant and understanding attention should be given to the human machinery. The Edison system in New York has in its history shown itself to be already moved by

both these desires; and this attitude, long since become a habit, will doubtless lead it continuously to make use both of the newest electrical inventions and of the farthest sighted policies toward those whom it employs.

The encouragement of ambition among its forces will, in coming years, be one of the most important endeavors of The New York Edison Company. At present in certain departments record is kept of the work of each individual, and an effort will be made to promote him whenever suitable opportunity offers. It is hoped to develop this practice: first, by arranging educational courses which will bear upon the business and technical affairs of the company; and second, by increased personal interest in the capabilities of each employee.

Present engineering practice seems to point to the continued—and perhaps increasing—use of very large generating units. Thirty years have seen a growth from 125 horse-power "jumbos," considered enormous in their day, to turbines with a capacity of 30,000. This means that the largest generators of the Edison system today are two hundred and forty times as powerful as those installed in 1882, and something more than eight times as powerful as the biggest employed when the first Waterside station was opened. While it is perhaps impossible to calculate the rate of future growth, it is safe to assume that generating units have by no means reached the limit of their capacity and to predict more marvels in this direction.

Having thus touched on tendencies, already mani-

fest, which are leading to an even bigger central station system efficient in all its parts, harmonious and well-knit, what are the services which it will be able to perform for the community? Do they not consist in the enlargement and completion of those it carries on today?

Here it will be well to recall for a moment a principle to which this organization has adhered ever since the opening of the old Pearl Street station. This is the matter of coöperation with all public authorities. When electric illumination was new, it was the custom of the First District office to report to the Board of Fire Underwriters all methods found to be dangerous, and to seek with this board to insure safety in every way. The company's present policy of hearty coöperation with city and state officials and with the Public Service Commission, will be carried into the future, favoring always the voluntary reduction of rates whenever conditions warrant this step. Today, for any given amount of current purchased, customers get fully three times as much light as they did in 1882. But Edison himself is of the opinion that a time is coming when, by still further improvement in lamp manufacture, current will be made to yield ten times as much light as formerly.

To suggest in outline what Edison Service may accomplish, it is only necessary to consider once again the skyscraper, the factory and the home as representing three great branches of interest to all New York's inhabitants. The skyscraper may be used figuratively to embody commercialism; the

A GLIMPSE OF THE OLD GRAND CENTRAL STATION
Drawn by Joseph Pennell

factory, industrialism; and the home, all the personal and intimate relations of life.

In all three of these departments it will be the province of electric supply to lessen drudgery and to promote health and safety. Separate plants will grow less numerous because of the impracticability of maintaining them in the face of increasing land values, and because it will be found safer not to place high-pressure steam-boilers in the basements of buildings housing many hundreds of people. In the business office, current will be used for mathematical calculations, dictation, drafting and for many other tasks which would otherwise take human time and energy. An indirect result will be the making of bookkeepers' and stenographers' work less monotonous.

In factories, electricity will do away to a large extent with dust and dirt, and the use of direct connected units will bring back somewhat of the personal element, since the "hand" will have control and understanding of his own machine. Reduction of noise, improvement of ventilation, prevention of accident, and possibility of more attractive surroundings will do much to make life pleasanter for the thousands of men and women who provide the markets with commodities.

Acting as a connecting link between the factory and the office and serving the home as well, the electric vehicle will become a more and more important item in New York life. Its recent strides into public favor have been described elsewhere, and as to its future usefulness, Edison himself has spoken. In an

THE ELEVATED
A lithograph by Joseph Pennell

article for *Popular Electricity* in June 1910, he said:

"There is absolutely no reason why horses should be allowed within city limits; for between the gasolene and the electric car, no room is left for them. They are not needed. The cow and the pig have gone, and the horse is still more undesirable. A higher public ideal of health and cleanliness is working toward such banishment very swiftly. . . . Many people now charge their own batteries because of lack of facilities; but I believe central stations will find in this work very soon the largest part of their load. The New York Edison Company, or the Chicago Edison Company, should have as much current going out for storage batteries as for power motors; and it will be so some near day."

An indication that central station service is destined to supply current for other forms of transportation, is already at hand. This is furnished by the fact that during the past summer the Third Avenue Railway Company drew up a contract under which The New York Edison Company took over the former's power plant at Kingsbridge. It thus became part of the central station system which, in return, supplies for the propulsion of street cars a 30,000 kilowatt load. Although the Kingsbridge station was in excellent condition and had been well conducted, the railway company has deemed it best to confine itself to the transportation problem, leaving the manufacture of power to those who are specialists in that undertaking. This plan, which went into action in October of 1912, probably not

only foretells the coming of a time when car lines and subways will cease to make their own current, but also foreshadows the arrival of an era when every industry and interest of the city will depend upon one great central station for its electric energy.

In the home, also, electricity finds a rich field, for possibilities in this direction are only just beginning to be realized. When the day arrives that every housekeeper can bring central station service to her aid in many tasks, then the conduct of the home will become a kind of domestic engineering. Women will be less unwilling to enroll themselves as cooks, laundresses or housemaids for their calling will stand on a different plane; and housework, one of the oldest, most necessary—and therefore most honorable—of occupations will come into its own.

This, however, by no means exhausts the accounting of useful and humane purposes to which electricity may be put as time goes by, for to do so in the space of a few concluding pages would be impossible. But it serves to show that in the New York of the future the central station will help in a measure to lessen men's burdens, to make lives happier and to dignify all forms of labor.

HIGH BRIDGE
Drawn by Joseph Pennell

LIGHT INVINCIBLE

The scintillators of the Hudson-Fulton Celebration

Index to Illustrations

INDEX TO ILLUSTRATIONS

INDEX TO ILLUSTRATIONS

INDEX TO ILLUSTRATIONS

INDEX TO ILLUSTRATIONS

INDEX TO ILLUSTRATIONS